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FEBRUARY 1960

AUTOMATIC ELECTRIC

TECHNICAL JOURNAL

VOLUME 7 NO. 1

GENERAL SYSTEM

FEBRUARY, 1960 VOL. 7, NO. 1

about our new name...

With this issue, the General Telephone Technical Journal assumes a new title, reflecting a change in the name of our Company. General Telephone & Electronics Corporation has formed a subsidiary, General Telephone & Electronics Laboratories Incorporated, with headquarters in New York City; the nucleus of this organization will be the Bayside, New York, Research Laboratories of Sylvania Electric Products Incorporated. To avoid confusion in names, the research and development organization at Northlake has reverted to its former name, Automatic Electric Laboratories, Inc. There will be no change in our function—we shall continue to engage in research and development in the field of communication, working with and for Automatic Electric's customers in the telephone industry in the United States and throughout the world.

AUTOMATIC ELECTRIC TECHNICAL JOURNAL

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COIN BOX CUSTOMER DIALING

By M. H. Esperseth

The Coin Box Customer Dialing (CBCD) system permits the prepay coinbox customer in a Director*-equipped office to dial any call that terminates within the same extended-area network. Thus, it extends dial operation to this class of calls, which have otherwise been handled on a manual basis.

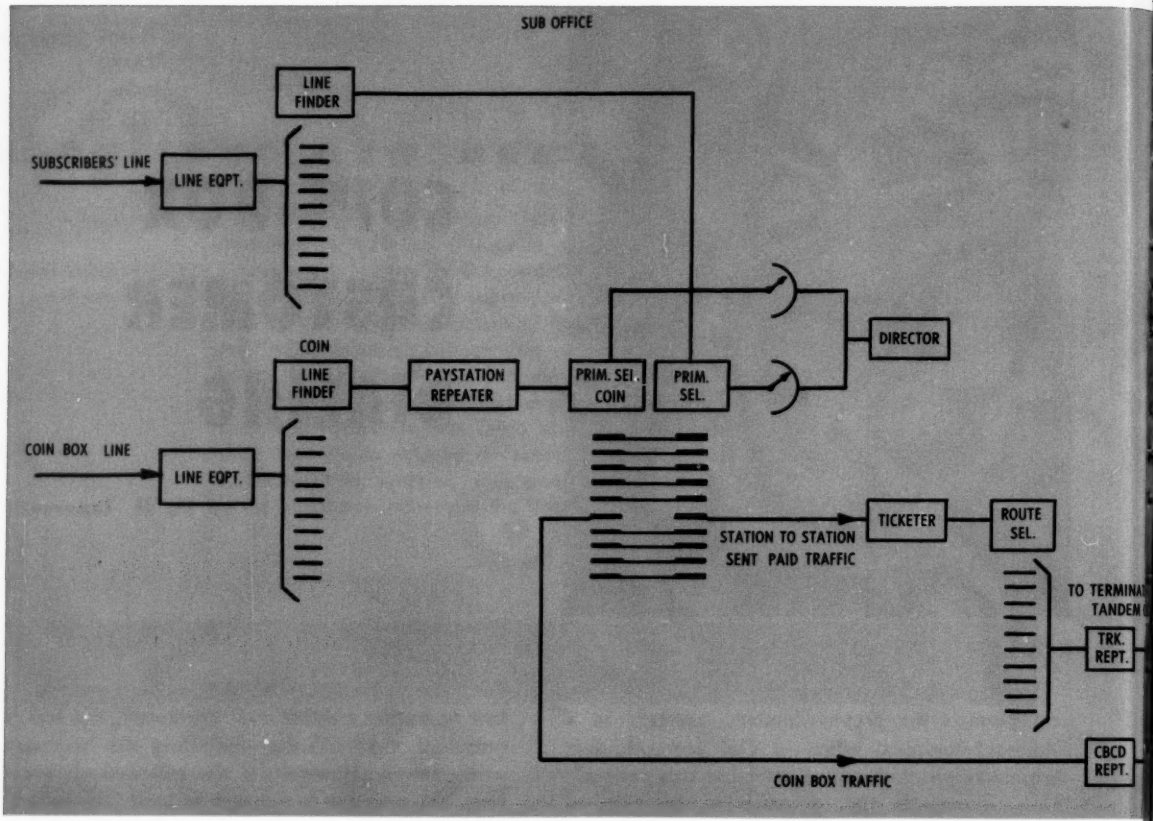
With manual operation, the customer dials zero, and the Director (register-sender) routes the call to a recording operator. The operator requests the called number, prepares a toll ticket, checks the applicable rate, and requests the charges for the initial three-minute period. Then she supervises deposit of such charges, and either dials or key-pulses the called number. If the call is not completed she refunds the coins upon calling-party disconnect. If the call is completed, she records the answer time and awaits a disconnect signal. At the disconnect signal, she records the disconnect time, calculates the elapsed conversation time, and collects overtime charges if the conversation lasted beyond the initial three minutes.

CBCD mechanizes all of the above functions, except for supervision of the coin deposits; on the 80 to 90% of calls that are concluded within the initial three minutes, the operator is called in only momentariiy, for the single purpose of monitoring the coin deposit for the initial period. Once the coins are deposited, the operator releases and is free to handle another call; thereafter, the call is processed automatically—including the necessary coin controls. However, if the call extends overtime, the operator is signaled to notify the calling party, to place a hold on the call, and, upon a disconnect signal, to monitor the coin deposit for the overtime.

CBCD is designed to handle the high volume of coinbox traffic within the Los Angeles Extended-Dialing Area, which serves some 2,800,000 telephones within 1500 square miles. The first installation was cut over in October, 1959, at San Fernando, a property of the California Water & Telephone Company; it will also provide CBCD service for paystation traffic originating in Granada, Sepulveda, Pacoima, and Sylmar offices. In this greater Los Angeles area, the intra-area coinbox traffic charges for the initial three minutes will range from 10¢ to 40¢.

Most independent exchanges in this area are equipped with Type "A" SATT systems, including Directors to provide the code conversion and flexibility required in a network of this type. The ticketing system provides automatic recording facilities for the tremendous volume of station-to-station "sent paid" traffic within the area.

DIRECTOR is a registered trademark of Automatic Electric Company



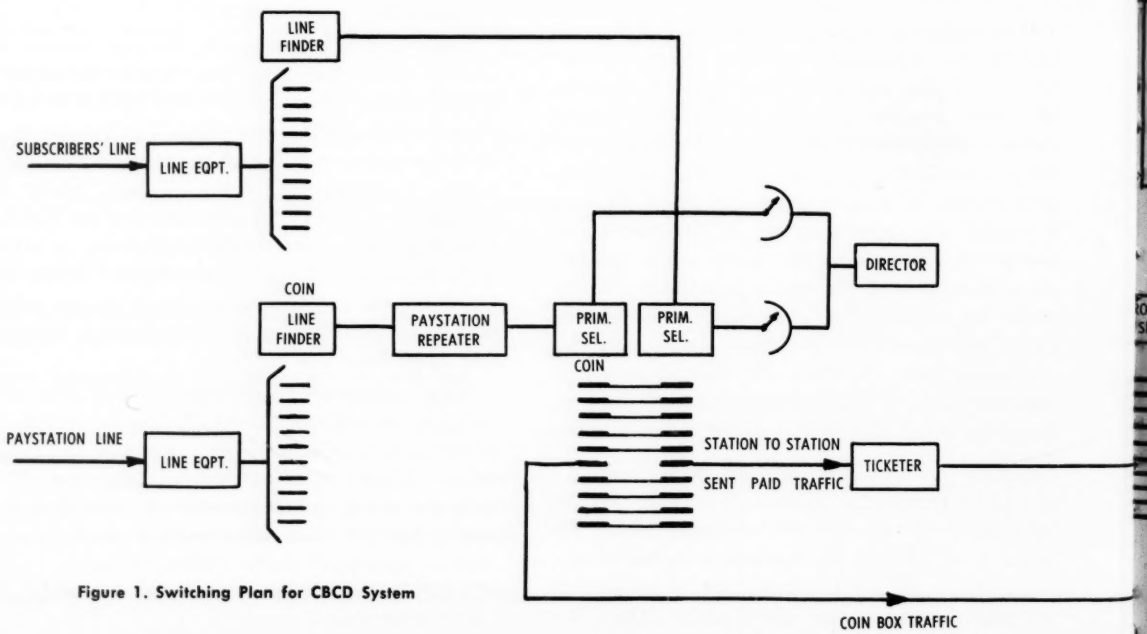


Figure 1. Switching Plan for CBCD System

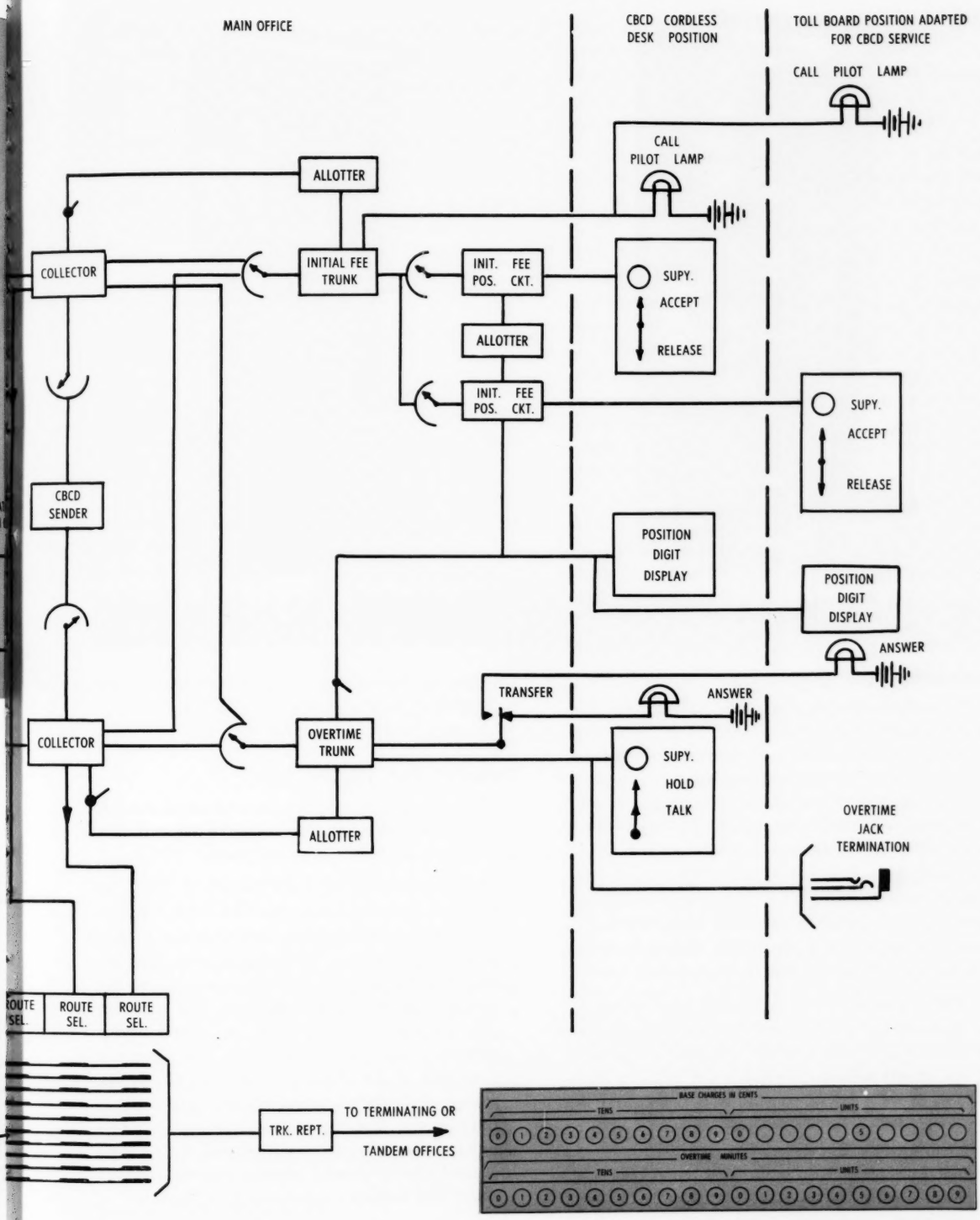


Figure 6. CBCD Position Digit Display

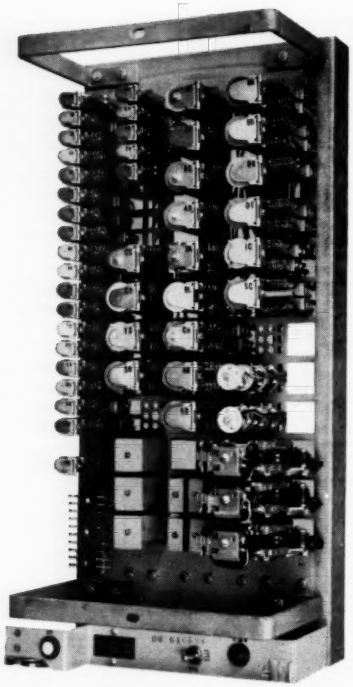


Figure 2. Collector Unit

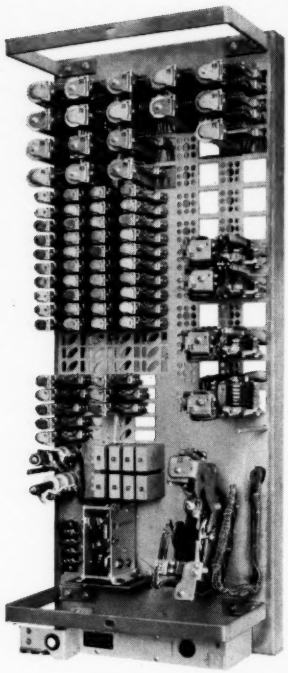


Figure 3. Sender Unit

Switching Plan (Figure 1)

In a Director-equipped office, primary selectors are provided in the first selector rank; upon seizure, the primary selector accesses an idle Director, which returns dial tone, signaling the subscriber to start dialing. In mechanizing coin-box traffic, CBCD takes full advantage of the Directors, which perform their usual functions of registering the called number, translating, and outpulsing. In addition, in conjunction with the common translator, they rate the coin-box call, and insert the initial rate information as a part of the routing code for subsequent use by the CBCD equipment.

The paystations are segregated and served by a separate group of linefinders and primary selectors. In addition, a prepay paystation repeater* is interposed between linefinder and primary selector, to provide initial deposit supervision, and the necessary coin controls on local calls.

With CBCD, the paystation customer dials the called number in the same manner that a subscriber dials a station-to-station call direct. The Director register-sender routes the call to the CBCD equipment and releases; the CBCD equipment takes over processing of the call.

The Prepay Paystation Repeater, by K. F. Steinhauer, Automatic Electric Technical Journal, May, 1953.

Collector Unit (Figure 2)

The collector, the basic control unit of the system, is seized through the banks of the primary selectors. It has 6 major functions:

(1) It receives the digits outpulsed from the Director, steers the first two into storage relays, and repeats the following digits into the sender. Referring to Figure 1, it can be seen that the first digit outpulsed by the Director sets up the primary selector, which seizes an idle collector. The second and third digits are stored in the collector. The first digit stored represents the tens digit of the charges (0X¢ thru 9X¢); the second digit stored represents the units digit of the charges. Since there are only two possible units digits—0 and 5—this second stored digit is used also to record sending control information. The collector interprets it as follows:

Digit 7—a call to a step-by-step office with a units digit of 0.

Digit 8—a call to a step-by-step office with a units digit of 5.

Digit 9—a call to a common-control office with a units digit of 0.

Digit 0—a call to a common-control office with a units digit of 5.

Digits 7 through 0 were chosen to allow maximum time for a collector to find an idle sender.

(2) While it is recording the rate information, the collector accesses an idle sender. If a sender is not attached in time to receive the switch-positioning digits, the collector returns busy tone and no further action is taken.

(3) Upon recognizing the release of the Director, the collector calls for the Initial-Fee trunk circuit so that the trunk can signal for the services of an operator.

(4) Upon receiving answer supervision, the collector automatically times out the initial period of three minutes. During the overtime period, the collector transmits one-minute marks to the overtime trunk for accumulation. This method of accumulation minimizes the equipment requirements for the collector.

(5) Upon completion of the initial-charge period, the collector calls for an overtime trunk which, in turn, signals for the services of an operator.

(6) When the operator has been accessed for Initial-Fee service, the prepay paystation repeater is locked out from further refund control. Thereafter, the collector must control the refund action in case the call is abandoned, or is not completed.

The collector also provides various supervisory and control features. A supervisory lamp indicates the progress of each call. An indication can be provided for the chief operator when a call is waiting for the services of an overtime operator. A coin-alarm lamp indicates when the refund voltage is being cycled. Controls are provided for peg counts of total call attempts and of completed messages. Access is also provided to a portable test set for general routining of the collector circuit.

Sender Unit (Figure 3)

Storage of the switch-positioning digits in the sender permits the Director to clear out, and provides time for the operator to be called in to monitor deposit of the initial charges. To minimize delay in completing calls to a step-by-step office, the sender immediately outpulses all but the last two digits.

When the operator releases after the initial rate charges have been deposited, the sender outpulses the last two digits of a call to a step-by-step office, or all digits without interruption on a call to a common-control office.

The sender will recognize a "stop send" condition during outpulsing, and extend the interdigital period in order that a flash busy can be distinguished from a stop-send condition. If the stop-send condition is removed within 5 seconds, sending will proceed; should it persist for more than 5 seconds, or if a flash busy is recognized, the sender signals the collector to return busy tone, and then releases.

A supervisory lamp indicates idle, busy and abnormal conditions. Controls are provided for an "all senders busy" condition and for a peg-count meter. Access is provided to a portable test set for sender routining.

Initial-Fee Unit (Figure 4)

Upon signal from the allotter, the Initial-Fee trunk finds the collector calling for service. After switch-through to the collector, the trunk signals an operator by lighting a Call pilot lamp which is common to all equipped positions. An available operator operates her Accept key momentarily, and the trunk-hunter switch finds the Initial-Fee trunk that is calling for service. The Call pilot light is extinguished, and a guard lamp lights at the position that switches-through to the trunk. The trunk then reverses the loop to the calling party, preparing the paystation repeater for subsequent coin-control action. A short pulse of refund voltage (—110 V., d.c.) is returned to refund the initial deposit.

A relay pulse-generator in the position-control circuit simultaneously steps a rotary switch in the collector (through the Initial-Fee trunk), to transfer the initial charge information.

The initial charge is displayed in numerical form on the common display panel at the operator's position; she requests and monitors the deposit of the charge. Coin controls are available to the operator in case the automatic refund fails, or in case of a questionable deposit. The operator

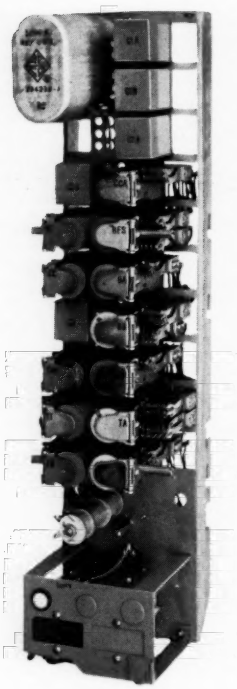


Figure 4. Initial-Fee Trunk Unit

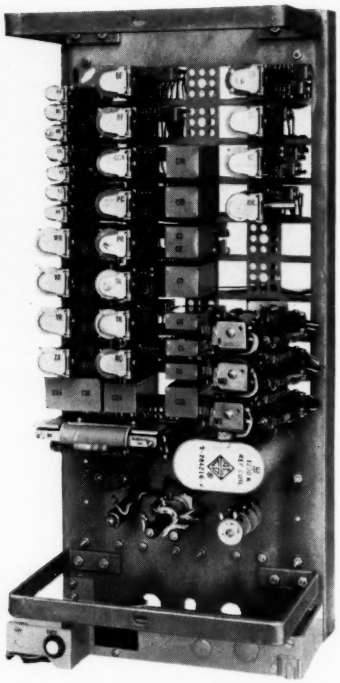


Figure 5. Overtime Trunk Unit

operates the Release Key, to clear her position and release the Initial-Fee trunk. The collector and sender then attempt to complete the call.

If the calling party refuses to deposit the charges, or some abnormal situation arises, the operator can operate the release and coin-control keys simultaneously to signal the collector to return busy tone and block any further progress. The Initial-Fee circuits will release. An indication that a call is waiting for the Initial-Fee service is available for the chief operator's supervision.

Overtime Trunk Unit (Figure 5)

When the collector records three minutes of time, an allotter is signaled, and it assigns an idle Overtime trunk to find the collector calling for service. When it is found, the operator is signaled and the initial-charge information is transferred from collector to Overtime trunk.

The operator accepts the call by plugging the cord into the jack termination and operating the Talk key in the toll board (or by operating the Talk key in a cordless desk position). The Talk key transfers the initial-charge information to the display lamps at the position (Figure 6, Page 5). The operator throws the Coin-Collect key to collect the initial charges previously deposited in the coin chute, states the overtime conditions, and places the call in a hold position.

Overtime conversation begins, and each minute the collector passes a "minute mark" to the Overtime trunk, where it is accumulated on a tens switch and on a units switch to a maximum of 99 minutes. When the called party releases, the operator's supervisory lamp is flashed at 60 IPM; if calling party releases, the lamp flashes at 120 IPM.

When the operator re-enters the connection, the base-charge information and the number of overtime minutes will be displayed (Figure 6, Page 5); the operator translates this information into the overtime charges. For example, if the display reveals a 15¢ charge for the base period, and two overtime minutes, the operator checks her bulletin to find that the overtime charge for the 15¢ call is 5¢ per minute. She requests an overtime charge of 10¢.

A re-ring facility is available to recall the calling party. Coin controls are available for returning

the coins in case of questionable deposits. The Overtime trunk is also under operator control: if desired, she can collect overtime charges; otherwise the paystation repeater automatically collects the coins upon calling-party release.

The overtime trunk is provided with peg-count controls, a progress supervisory lamp, and access to a portable test set.

Operator Services

Operator services can be provided through a special cordless desk position designed for CBCD service, or through Automatic Electric Type 20 or 30 toll-board positions adapted for CBCD service.

For Initial-Fee Service, a key-ended circuit and an associated position-control circuit serving up to 25 Initial-Fee trunks is provided for either the desk position or the toll-board position. Overtime trunks are key-ended at the desks and jack-ended at the toll board. Two optional arrangements are provided for Overtime trunk terminations:

1. The Overtime trunks are terminated at the desk position, with manual transfer to an alternate toll-board position for night or emergency service.

2. All operator services are provided from toll positions adapted for CBCD service; no CBCD desk positions are provided.

Overtime trunks are assigned in groups of five, terminated at a desk position or at a toll-board position; thus each trunk group is individual to a position (Figure 7). This arrangement permits the talk-key operation to control the position digit display, and obviates the need for digit-recording and storage facilities in the position circuit to control the digit display.

Calls for overtime service are allotted in sequence to the various positions. If a position is not staffed, the five associated overtime trunks are automatically marked busy. A busy key at the position also marks the associated trunks busy to incoming traffic, permitting the operator to clear her position.

Trunk Repeater Circuit

This is a one-way outgoing coin-pulse repeater that permits paystations in contiguous Director-equipped offices to be served by the CBCD equipment in a centralized location. Digits outpulsed by the Director register-sender in the contiguous office are repeated as ground pulses on the ring side of the trunk to a collector at the CBCD center. When the Director has completed its function and releases, the coin repeater sends a battery pulse over the tip side of the line, to signal the collector that the Director has released. The circuit then repeats the coin-control functions, and signals the collector when the coins have cleared the coin chute (a coin-alarm lamp will light if the coins fail to clear); it also repeats the re-ring function of the distant operator. The repeater can be busied out from its associated collector in the distant office. Circuit routining is performed through use of a standard test telephone; additional test jacks permit simulating the Director release action.

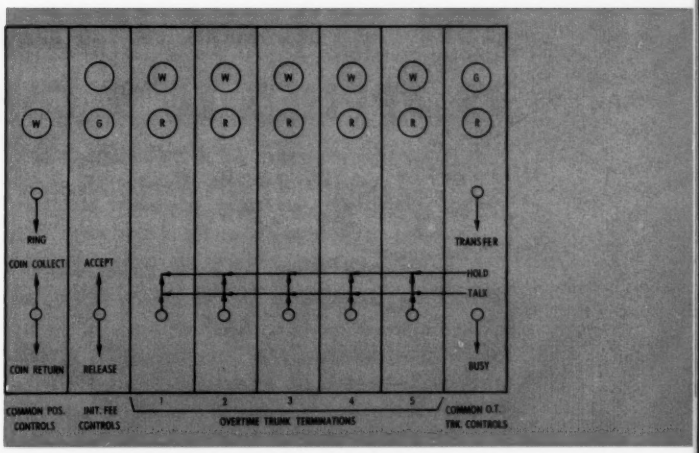


Figure 7. CBCD Position Keyshelf Display

Testing and Monitoring Features

A supervisory lamp is mounted on each collector, sender, Initial-Fee trunk, and Overtime trunk. Bright, dim, and flashing signals indicate the progress of each call, and various alarm conditions. Multiple supervisory lamps are provided at a common point for overall supervision of the system.

Two portable test sets are provided. One is designed to routine either a collector or a sender, and to test all their functions previously outlined. The other test set routines the Initial-Fee trunk and the Overtime trunk. A ten-conductor patch cord connects the proper test set through a Jones socket on the unit to be tested. An operational routine is made of the circuit features—seizure, pulsing, coin-controls, re-ring, and release.

A standard portable speed and percent-make test set is used to check the pulsing characteristics of pulse generators in the sender, Overtime trunk, and Initial-Fee position circuit.

NEW DYNAMIC IMPEDANCE-MATCHING CIRCUIT AS APPLIED TO A CONFERENCE REPEATER

This paper was presented by Mr. Grandstaff at the AIEE Summer and Pacific General Meeting, Seattle, Wash., June 21, 1959.

By O. D. Grandstaff

Occasionally a telephone conversation will involve three parties, with the third party talking on an extension telephone. Another form of group conversation involves the interconnection of several telephone lines for a conference call. Here the lines are connected together in a conference circuit at the telephone exchange, in such a manner as to provide optimum transmission and impedance matching. Small conference groups can be coupled through repeating coils; larger groups and conference circuits employed on toll switchboards need an amplifier to maintain satisfactory transmission levels. Current practice is to use telephone repeaters for this purpose.

During the establishment of a conference call, lines are added successively to the conference circuit until the desired number of parties are connected. Furthermore, some parties may disconnect before the conference is concluded. These changes substantially alter both the impedance and the voice signal power requirements in the conference circuit. To improve the stability, dummy loads are usually connected when the party disconnects, but precise compensation cannot be obtained by this method, as the impedance of lines connected to a conference circuit may vary considerably. Therefore, for a new conference repeater an amplifier with special input circuits has been developed that can keep each line properly terminated and operate with good stability, regardless of the number of lines set up for a conference call. Since modern transmission standards provide uniform transmission levels in both local and toll switchboards, it is not necessary to introduce gain in the conference repeater, but the original level must be maintained, with any number of conference lines connected.

These requirements imposed several problems in the design of the conference repeater circuit. First, each line should be properly matched for impedance, by the inputs of the conference repeater; a mismatch can adversely effect the anti-sidetone circuit of the telephone or the hybrid balance of a toll circuit repeater. Second, the amplifier must have the unique characteristic of delivering the same output level regardless of variations of load. Third, any party in the conference must be able to talk at will, and be heard by all other parties.

The new conference repeater circuit is arranged to meet the above requirements with as many as twelve conference lines. A new dynamic impedance-matching circuit provides stable operation without need of the balancing network normally required in similar circuits where hybrids are used.

Principles of Operation

The principles of operation of the conference repeater circuit are shown in Figure 1. This is a two-party connection in which a generator, G1,

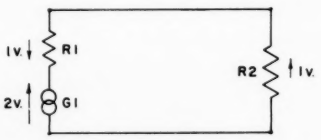


Figure 1. Telephone and Load Correctly Impedance-Matched

represents the transmitter of the talking telephone; resistor R1 is the internal impedance of the transmitting circuit; R2 is a load impedance representing the listening telephone. If the generator or talking telephone has an output of two volts, one volt is dissipated in the source, R1, and one volt is dissipated in the load resistor, R2. Under this condition the load impedance matches the source impedance and provides the ideal condition.

Figure 2 shows a conference repeater circuit in which G2 represents the transmitter of the talking telephone; R3 its source impedance; and R4, R5,

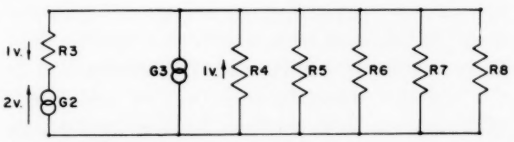


Figure 2. Telephone and Conference Circuit Impedance-Matched

R6, R7 and R8 the load resistances of five listening telephones. These load resistors in parallel would normally cause a mismatch of impedance with the source impedance, R3, but in this circuit a generator, G3, has been added to produce a voltage across R4, R5, etc., of the same value that existed across R2 in Figure 1. Therefore, if generator G2 generates two volts, one volt will be dissipated in resistor R3, and one volt will exist across resistors R4, R5, R6, R7, and R8: here is the same loading of the source as in Figure 1. Under this condition the same current will flow from generator G2 of Figure 2 as flows from generator G1 of Figure 1. Also, each load resistor, R4 to R8, will have one volt across it—the same as load resistor R2 of Figure 1. In this manner of talking the telephone is kept properly terminated, and the several listening telephones receive full-strength signals.

As long as generator G3 maintains the voltage across the load circuit, additional loads may be added or removed without altering the transmission level on the other conference lines. In the conference repeater circuit, generator G3 is an electronic amplifier which uses an output circuit of the cathode-follower type. It has sufficient inherent negative feedback so that telephones may be added or removed with negligible effect on its output voltage.

Figure 2 shows transmission in one direction only—from generator G2 and R3 to all the other loads. Since the requirements are that speech may originate from any telephone, the conference circuit must be a symmetrical — arranged for any party to either talk or listen. This requirement presents a problem, since it involves two-way voice transmission with amplifier. An amplifier or voice repeater usually uses a hybrid circuit to detect the direction of power flow, but in a conference repeater, hybrid circuits are not practical because large variations in impedance occur as several lines are switched onto or disconnected from the conference repeater; these variations create excessive unbalance in the hybrid circuit, and cause oscillation or singing.

Directional Discrimination

For detecting the direction of power flow, the conference repeater circuit uses a new method which does not require a balancing network. Line voltage and line currents are rectified by german-

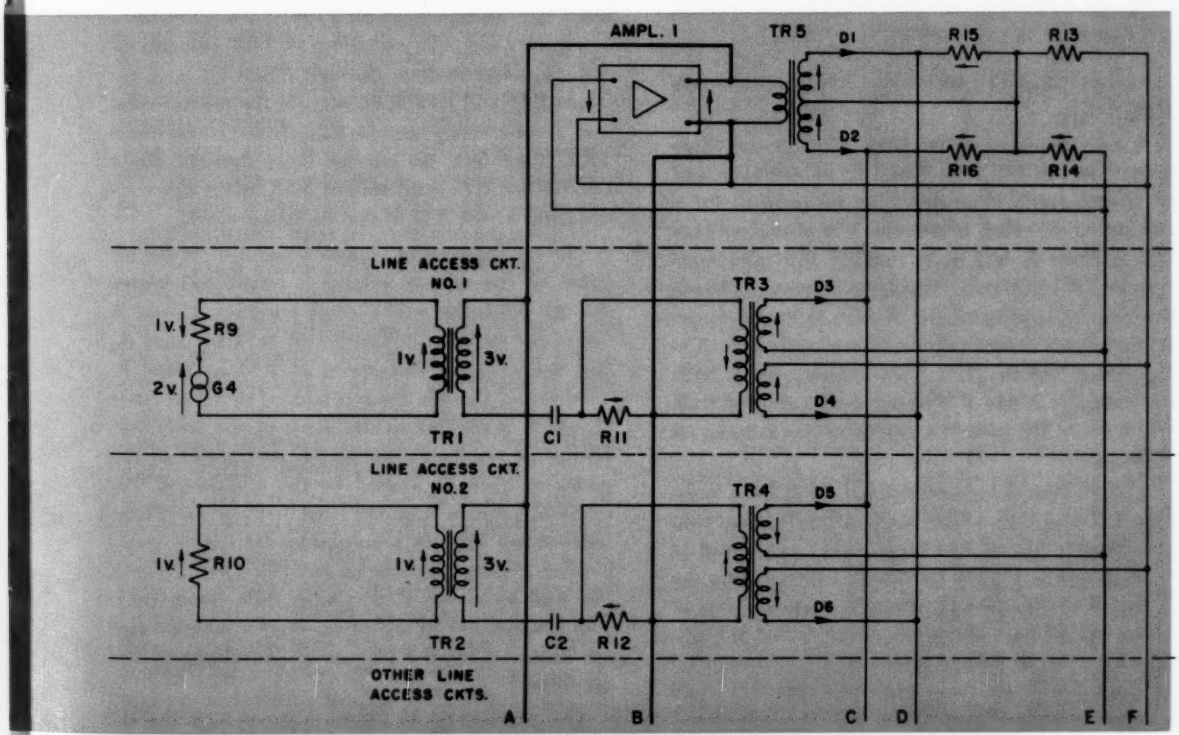


Figure 3. Conference Repeater Circuit

ium diodes for comparison of their polarities, to determine if the lines are carrying incoming or outgoing signals. Incoming currents control the amplifier, outgoing currents are prevented from having any effect on it. This is accomplished as shown in Figure 3. Generator G4 and resistor R9 represent a talking telephone connected to line access circuit No. 1. Voice signals from G4 pass through transformer TR1, capacitor C1, and resistor R11, to the main signal bus leads A and B. An amplifier, AMPL-1, has its cathode-follower output connected to the A and B leads, and functions the same as generator G3 of Figure 2. The listening telephones, such as R10, also are connected across the A and B leads. Load current flows from the A and B leads through resistor R12,

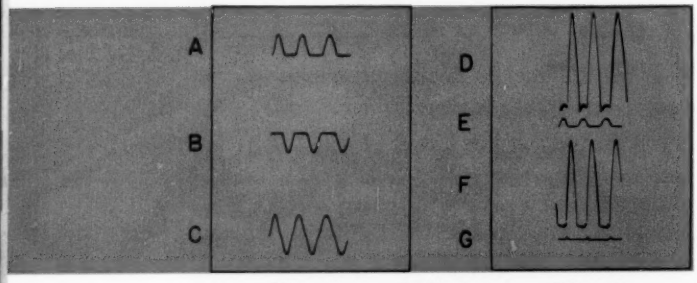


Figure 4.

Figure 5.

Oscillograms

capacitor C2, and transformer TR2, to the load, R10.

A conference repeater may have several line-access circuits like Nos. 1 and 2; all are alike and each may function at any time as a circuit for a talking or listening telephone. The signal voltage across leads A and B is applied through transformer TR5 to provide a voltage reference. During positive half-cycles of the A and B lead voltage, current flows through diode D1 and resistor R15 to the center tap of TR5. This causes positive half-cycles of the A and B lead voltage on resistor R15, while diode D2 prevents any reference voltage on R16.

The current references are obtained from resistors R11 and R12, which are small resistances (approximately 5% of line impedance) connected to leads A and B. Signals flowing into or out from the A and B leads cause IR drops in these resistors of about 5% of the voltage across the A and B leads. The IR drop or voltage across R11 is proportional to the voice signal from generator G4; this small voltage is stepped up about 4:1 through transformer TR3 to have a better amplitude for diodes D3 and D4 and the input to the amplifier. On positive half-cycles of the A and B lead voltage, a secondary winding of TR3 causes current to flow through diode D4, resistor R15, and resistor R13, back to the winding of TR3. The voltage drops developed across resistors R15 and R16 are of no consequence, but the voltage drops across R13 and R14 are connected to the input of the amplifier.

Resistor R12 has an IR drop proportional to the load current. The voltage drop is opposite in polarity to that of the IR drop of R11, since it is due to current flowing out from the A and B leads. If this voltage were impressed on the input of the amplifier, it would subtract from the voltage applied to the amplifier by resistor R11; since the input would thus be reduced, it would no longer be proportional to the incoming signal. Therefore, the circuit must function to prevent the outgoing signal voltage of R12 from reaching the amplifier. This is accomplished in the following manner.

Transformer TR5 is designed to always have a larger voltage at each half of its secondary than the voltage at a secondary winding of TR4 (even when one or two extension telephones are used with the listening telephone, causing an abnormally high voltage drop on R12). Thus, when voltage from a secondary winding of TR4 attempts to cause current to flow through diode D6 and resistors R15 and R13, it encounters the greater voltage drop already across R15 from transformer TR5. Therefore, no current flows through diode D6, resistor R15, and resistor R13, when the voltage drop across R12 is due to load current.

The oscillograms in Figures 4 and 5 show the relation of the voltage reference waves and waves due to the input and output currents. Figure 4 shows the positive half-cycles of R13 in trace A, and the negative half-cycles of R14 in trace B. The sum of these is the reproduced signal of trace C, which is applied to the input of the amplifier. (Note the small notches, at the zero points of the cycles in trace C, caused by the addition of the rectified positive and negative half-cycles. These notches are kept to a minimum by use of gold-bonded germanium diodes for D3, D4, D5, and D6, and by circuit design with little phase shift. The notches are of high-frequency character and are removed by the frequency limitations of the amplifier.)

The oscillogram in Figure 5 shows how the incoming and outgoing signals are selected or re-

jected due to their phase relations. Traces D and F are half-cycles of reference voltage on resistor R15, rectified by diode D1. Current from diode D4 flows through resistors R15 and R13, while diode D1 is non-conducting. Trace E shows the half wave of voltage on resistor R13. Note that the positive peaks of trace E occur between the high peak periods of trace D, the small peaks near the bottom of trace D in phase with waves of trace E are due to current flowing through diode D4, R15, and R13, while Diode D1 is non-conductive.

Waves in traces F and G show the rejection of signals due to outgoing currents. Since the reference voltage and IR drop of R12 are in phase, diode D6 is conductive at the same time diode D1 causes large positive half-cycles on R15. The absence of positive half-cycles of the signal on trace G shows how effectively signals due to outgoing currents are rejected. Only small notches remain, which are lost in the amplifier—like the notches in trace C.

Complete Repeater Unit

A conference repeater equipped with six line-access circuits is shown in Figure 6. The common amplifier, at the top of the unit, is a conventional vacuum-tube amplifier, using resistance-coupled triode voltage-amplifiers to drive the cathode-follower output tube. One control, R6, sets the gain to provide the correct input impedance in the manner explained for generator G3 in Figure 2. The access circuits are located in the middle of the unit. Equipment at the bottom includes a busy lamp, a test jack, and a busy switch associated with the input of each access circuit.

Figure 6. Conference Repeater for Six Lines

Operating characteristics of the conference repeater are shown in Figures 7, 8 and 9. These curves show voice-frequency signals originating at one telephone while the number of listening telephones is increased from 1 to 11. Curves for telephones connected in multiple without benefit of a conference repeater are shown for comparison. Figure 7 shows the impedance or load on the line of the talking telephone. Curve A shows the decreasing load impedance as listening telephones are added in multiple. Curve B shows the load impedance as telephones are added to the access circuits of the conference repeater. It is clear that the input impedance of an access circuit, while it is receiving a signal, varies only slightly as the number of listening telephones is increased.

Figure 8 shows the signal level at the listening telephones, in decibels. In curve C, the level decreases rapidly as listening telephones are added in multiple. Curve D shows the level at the listening telephone connected to a line access circuit. The level changes about 1 decibel as the number of listening telephones is increased from 1 to 11.

Figure 9 shows the frequency response of the conference repeater at up to 3000 cycles. Above this level the attenuation increases rapidly. This characteristic is built into the amplifier to eliminate the high-frequency distortion due to the notches shown in trace C of Figure 4. As a result, only a small amount of distortion is caused by the rectification of the incoming signal and re-combination of the waves. Only the lower frequencies (below 500 cycles) show any evidence of the notches caused by the re-combination.

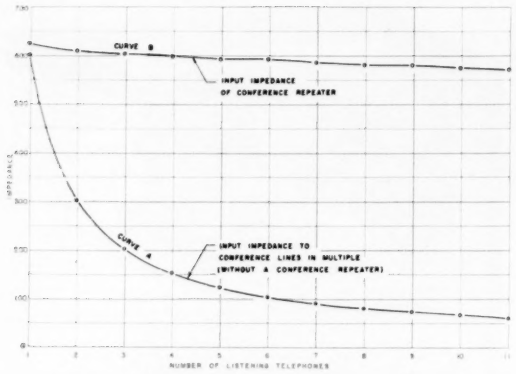


Figure 7. Input Impedance of Conference Repeater

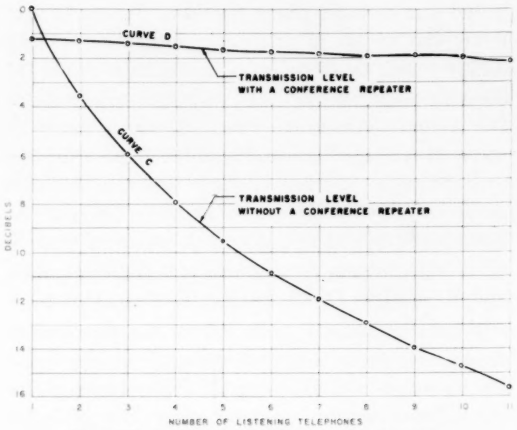


Figure 8. Output Level of Conference Repeater

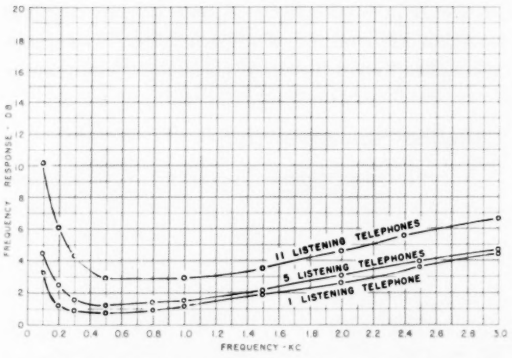


Figure 9. Frequency Response of Conference Repeater

In a telephone conference, more than one person may speak into his telephone at the same time; in fact, coincidence of speech is more likely than where the group is assembled around a conference table. The conference repeater can handle such simultaneous speech without difficulty, since each line access circuit is always ready to receive incoming signals. To test simultaneous response, three persons were asked to read paragraphs from three unrelated subjects. Three other persons were instructed to listen and each to concentrate on his particular subject. Each one was able to understand completely the transmission of his subject.

The conference repeater provides equipment frequently needed for group telephone conversations. It can be used in toll and local offices or in private exchanges. It is easily applied to either manual or automatic type offices. Its constant input impedance, fixed-gain amplifier, and inherent stability permits lines to be connected or disconnected without need of dummy loads or balancing networks.

NEW PRESIDENT OF AUTOMATIC ELECTRIC LABORATORIES, INC.

FRANK D. REESE

The Technical Journal welcomes to its Editorial Advisory Board Mr. Frank D. Reese, the new President of Automatic Laboratories. Mr. Reese succeeded to his new post with the appointment of Mr. Robert M. Wopat to the Presidency of General Telephone Company of Illinois, effective January 1, 1960.

Mr. Reese comes to Laboratories with a wide professional background in the communication field. He received his BS ADM. M.E. from Cornell University in 1939, and went to work for General Telephone Company of Fennsylvania as an Equipment Engineer. During World War II, he served with the United States Army Signal Corps, as an officer; he returned to General Telephone of Pennsylvania in 1945, and advanced to Chief Engineer in 1952. Mr. Reese became Engineering Director of General Telephone Service Corporation of New York in 1957, and held this post until his new appointment.

A NEW MULTI-FREQUENCY PULSING UNIT FOR INTER-OFFICE TRUNK SIGNALING

By R. P. Sanders

A multi-frequency pulsing unit which is capable of generating, distributing, and monitoring the audio tones required for inter-office MF signaling has been designed by Laboratories. Because it uses frequencies that lie within the voice-frequency spectrum, it can be used on any type of inter-office trunk capable of carrying speech signals. A high degree of accuracy is assured by self-checking facilities in the pulsing equipment.

Multi-frequency pulses are constructed by combining six voice frequencies in pairs, each pair representing one dialed digit. As can be seen in Figure 1, the frequencies of 700, 900, 1100, 1300, 1500, and 1700 cps are utilized to form fifteen different codes. Ten pairs designate the digits "1" through "0"; one pair signals the initiation of signaling (KP); one pair signals the completion of signaling (ST); the remaining three pairs are not used.

Digit	*Frequency—Pairs*
1	700 and 900 cps
2	700 and 1100 cps
3	900 and 1100 cps
4	700 and 1300 cps
5	900 and 1300 cps
6	1100 and 1300 cps
7	700 and 1500 cps
8	900 and 1500 cps
9	1100 and 1500 cps
0	1300 and 1500 cps
KP	1100 and 1700 cps
ST	1500 and 1700 cps
Unused	700 and 1700 cps
Unused	900 and 1700 cps
Unused	1300 and 1700 cps

Figure 1. Multi-Frequency Signal Coding Plan

The multi-frequency pulsing equipment is divided into four units:

Current-Supply Unit (Figure 2)—contains the circuit which generates the six audio-frequency tones. For normal central-office installation, two of these units are required, each unit carrying one-half of the office load, even though a single supply is capable of handling the entire load of a 200-position switchboard.

Tone Distributor Unit (Figure 7)—provides a means for distributing tones to operator positions.

Alarm Unit (Figure 9)—supervises the functioning of the previous units.

Tone Transfer Unit (Figure 10)—assures a continuous source of signal, by redistributing the load should a current-supply unit become disabled.

Current-Supply Unit

Each current-supply unit consists of six audio oscillators and their associated amplifiers. Printed wiring boards are employed, and transistors are used throughout. The transistors permit the use of standard central-office voltages to power the unit

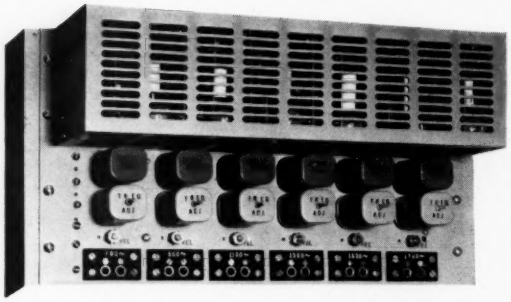


Figure 2. Current Supply Unit—showing voltage and frequency controls and jacks from which output signals may be monitored. The ventilated cover encloses six oscillator-emitter follower printed-circuit boards and six amplifier boards

and do not burden the office with demands for unique potentials to fulfill plate and filament voltage requirements. The six-volt tone-supply output is variable by a simple screwdriver adjustment, as is the frequency of oscillation of the individual oscillators. The voltage and frequency stability of the unit under conditions of changing temperature, supply voltage, and load, is demonstrated by the curves (Figures 3, 4, and 5).

The oscillator has the form of a modified Clapp* oscillator. Transistors are employed in the common-emitter configuration; bias is developed through the use of Shea's** familiar single-battery biasing scheme (Figure 6). The frequency of oscillation is determined primarily by inductance L_1 and capacitors C_4 and C_5. Capacitors C_2 and C_3 are ten times as large as C_4 and C_5. Since the common-emitter configuration results in a phase shift of 180 degrees between base and collector, and capacitors C_2 and C_3 produce phase-reversal characteristics through voltage divider action, the voltage developed across C_3 applied to the transistor between base and ground, creates an in-phase or positive feedback effect, enabling the circuit to sustain oscillation.

During manufacture, the unit is calibrated with respect to frequency by the addition of trimming capacitors in parallel with capacitor C_5. In the field, $\pm$ 1% adjustment of the frequency of oscillation can be made by altering the inductance of the variable inductor in the present circuit. The inductor consists of a coil enclosed within a magnetic ceramic cup-core. A movable ceramic core passes through the center of the coil; by withdrawing the core from the coil, the magnetic circuit is altered and a continuously variable frequency-control results. The Q of this coil is quite low (approximately 10) at its lower limit of inductance. To increase the effective Q of the inductive portion of the resonant circuit, and thereby increase the frequency stability of the oscillator, a toroidally wound coil exhibiting a Q of about 80 is used in series with the variable inductor.

To make the voltage output of the oscillator stable, two silicon diodes in parallel, and with their forward-current conduction directions reversed, are connected across capacitor C_4. The diodes serve to limit the voltage across C_4 to their

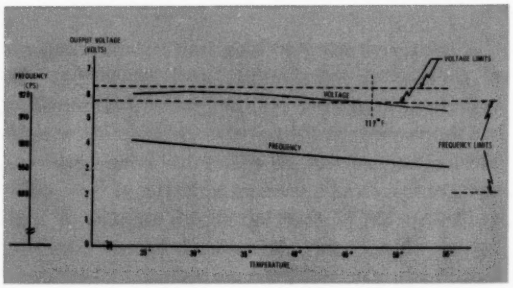


Figure 3. Frequency and Voltage Regulation of MF Current Supply with varying Temperature

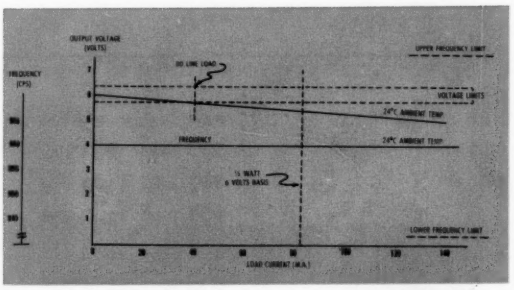


Figure 4. Frequency and Voltage Regulation of MF Current Supply with varying Supply Voltage

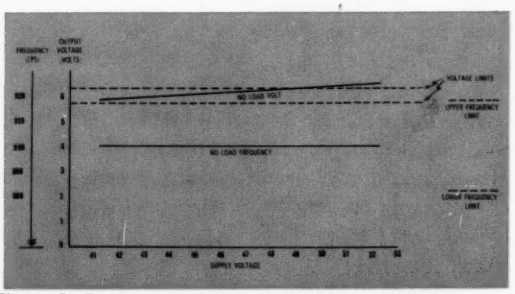


Figure 5. Frequency and Voltage Regulation of MF Current Supply with varying Load

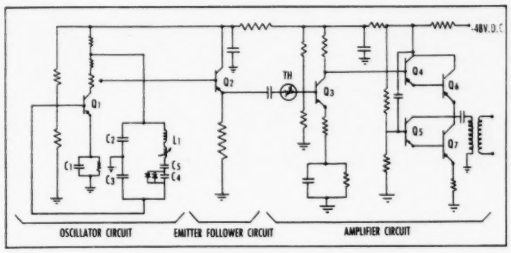


Figure 6. Current Supply Circuit

inherent forward voltage drops. When trimmer capacitors are added in parallel with C_4, the impedance (and therefore voltage ratio between C_4 and C_5) is altered so that a greater portion of the voltage drop appears across C_5. The amplitude of oscillation is thereby allowed to increase until the voltage drop across C_4 is again equal to the forward drop of the limiting diodes.

For adjustment of output voltage, a potentiometer is employed as a portion of the load resistance in the oscillator circuit. The voltage selected on the potentiometer is applied directly to the base of an emitter-follower. The high input impedance and low output impedance characteristics of the emitter-follower circuit qualify it as an excellent buffer amplifier to couple the load-sensitive oscillator to the amplifier circuitry. Although the base bias of this stage is dependent upon the setting of the potentiometer in the oscillator load circuit, excursions of base potential are not so great as to introduce signal distortion.

The audio signal generated across the emitter resistance of the emitter-follower is applied to the amplifier stage through a d-c blocking capacitor and a thermistor. The thermistor, a temperature-sensitive device possessing negative temperature coefficient properties, is employed to counteract decreases in a-c signal amplitude which occur when the active circuit elements (transistors and diodes) are subjected to elevated temperatures.

The first stage of the amplifier section is a conventional common-emitter voltage amplifier. The second stage consists of two pairs of transistors, operating as a push-pull amplifier. Each pair is connected in Darlington's* compound connection, producing an effective forward-current amplification factor (Beta) which is approximately the product of the Beta of each transistor. To assure symmetrical push-pull amplification, both the driver transistors (Q_4 and Q_5) and their power amplifier mates (Q_6 and Q_7) are matched with respect to amplification factors. The power amplifier is designed for class "A" operation to assure undistorted output. The 5.5 v. output is increased to 6 v. by an output transformer, which serves as the coupling medium between the current-supply and the tone-distribution circuits.

Tone Distribution Unit (Figure 7)

As well as providing a means of distributing the generated audio tones to operator positions, the Tone Distribution Unit prevents shorts on transmission lines from overloading the current supply. Consisting solely of resistors, it has no active elements. A portion of the distribution circuit, showing the distributing resistances and the means by which two audio tones are transmitted over the transmission lines simultaneously, appears in Figure 8. The upper keyset is shown impressing a 900 cycle tone and a 1300 cycle tone upon the transmission line simultaneously, thereby transmitting the coded digit "5." The lower keyset shows the

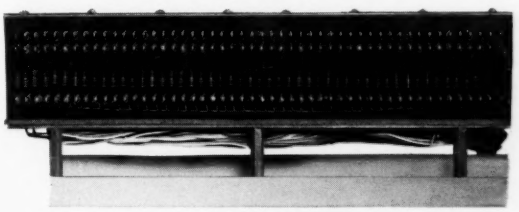


Figure 7. Tone Distribution Unit—Terminal Strip mounts 620 Ohm Resistors

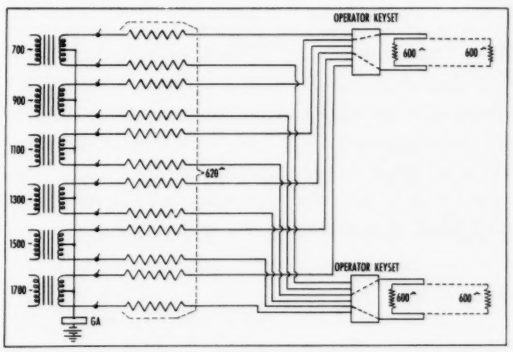


Figure 8. Method of Distributing Audio Tones to Operator Keyset Positions

digit "9" being transmitted. Note that should a ground appear on the transmission line, battery-connected relay GA would operate, and actuate a "ground" alarm.

Alarm Unit (Figure 9)

The current-supply units, in groups of two, are monitored by circuits designed to register an alarm should a malfunction occur. The most novel of these circuits is the voltage alarm circuit. Portions of the output signals of each pair of audio amplifiers in the current-supply unit are rectified by full-wave rectifiers. The rectified output of the 700 cps supply is compared with the rectified 'out-

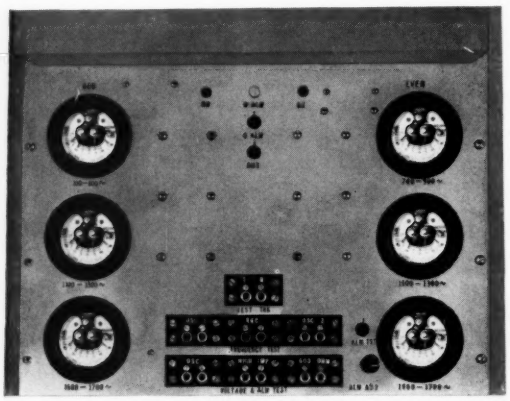


Figure 9. Alarm Unit

put of the 900 cps supply. Similarly, the 1100 cps and 1500 cps outputs are compared with the outputs of the 1300 cps and 1700 cps supplies, respectively. A sensitive voltmeter relay is used to detect a difference between the paired rectified outputs. An analysis of Figure 11 will show that when the level of outputs within a frequency pair is identical no current will flow through the voltmeter coil. However, when the output voltage of one tone generator deviates from that of its mate by more than 1.5 db, current flowing through the coil actuates the voltmeter relay, setting off visual and audio alarms within the central office.

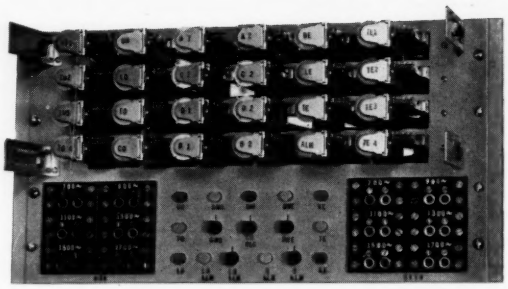


Figure 10. Tone Transfer Unit—mounts Relays, Switches, and Associated Circuitry required to effect load reassignment should one of the twelve tone-generators fail

Tone Transfer (Figure 10)

Should a current-supply unit fail, the alarm condition would activate the tone-transfer circuit. A network of conventional telephone relays would transfer the load normally carried by the afflicted tone-generator pair to the corresponding pair in the unit serving the other half of the central office. This transfer does not impose an intolerable burden on the "rescuing" current supply; actually, this load could be endured indefinitely. When the malfunction has been remedied, a manual transfer key can be operated to return the loads to their respective current supplies.

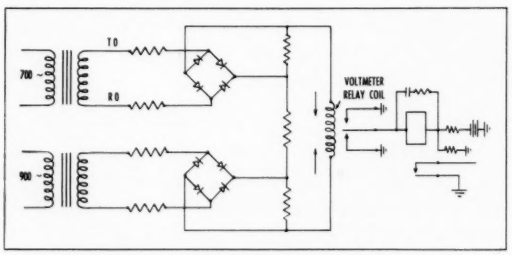


Figure 11. Voltage Alarm Circuit

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*"*An Inductance Capacitance Oscillator of Unusual Frequency Stability," J. K. Clapp, Proc. IRE, 36, 356 (1948).*

"Single-Battery Biasing," by R. F. Shea, Transistor Circuit Engineering, Wiley, 1957

MEMORY DEVICES APPLICABLE TO FUTURE ELECTRONIC SWITCHING SYSTEMS

By J. M. Bernstein

In today's electromechanical switching systems the function of "remembering" what action has been taken on a given telephone connection is performed by relays and stepping switches. Each set of relay contacts has two discrete stable states—open and closed—and this makes the relay a bi-stable device capable of storing a binary digit. A combination of these bi-stable devices can be used to store decimal numbers; the present "Codel" relay used in SATT systems is one which serves this purpose.

Electronic telecommunication switching systems of the future will require stored information in permanent, semi-permanent, and temporary memories. Such memory devices will be called upon to supply control information for a given operation in a few microseconds. These memory functions will be centralized in a common memory system, using a complex logical network to distribute the information as required.

This article explains and illustrates some typical memory devices which are undergoing research in our Laboratories. Since the terminology used is common in the field of electronic computers some definitions may be helpful.

Terminology

Access Time: The time interval between the instant at which information is requested from the memory and the instant at which this information begins to be available in useful form.

Address: An expression which designates a particular location in the storage or memory system.

Binary Cell: An elementary storage element which is placed in either of two stable states (as "open," or "closed," in the case of a relay).

Binary Digit: A single character of a language employing only two characters—"zero" and "one."

Bit: Abbreviation of "*B*inary Digi*t*."

Clock: A primary source of synchronizing signals.

Decoder: A network or system in which a combination of inputs is excited at one time to produce a single output. Sometimes called a "translation matrix."

Gate: A circuit having two or more inputs for signals of a binary nature, and a single output which is energized only when certain input conditions are met.

Instruction Code: An artificial language for describing or expressing instructions to be carried out by a switching system.

Read: The process of drawing information from a storage device.

Regeneration: The process of restoring a storage device to its previously undeteriorated state.

Register: A device capable of retaining small amounts of binary information (e.g., buffer register which provides a "cushion" between a read cycle and the next write cycle).

Remanence: Magnetic flux that remains in an energized element when the exciting energy is removed.

Reset: To place a binary cell in the initial or zero state.

Re-write: The process of restoring a storage element to its state prior to reading.

Storage Capacity: The amount of information, expressed in words or bits, that can be retained in a memory system.

Word: A group of binary digits containing sufficient information to perform a logical operation.

Write: The process of putting information into a storage device.

A Typical Memory System

Two types of selection are available for memory systems using binary cells:

Sequential Access

This method of selection, in which the complete memory is scanned once every memory-frame cycle

(each word is, in turn, read out, worked upon, and re-written) is suited to the stored-logic type of operation.

Random Access

This method of selection, in which any individual word is accessed according to the address received by the input circuitry (the address dictates the location of a particular word in the system, and only that word can be read out) is more suitable to the storage of information needed only on special occasions.

In a memory system there are two cycles of operation—a "write" cycle and a "read" cycle. During the "write" cycle, all information stored in the buffer register will be written into the memory; during the "read" cycle, the buffer register is free to accept information read from the memory. The switching system logic uses the information that has been recorded in the buffer register and rewrites it during the "write" cycle; or it modifies the information so that a new word is written; or it may erase all the information that has been buffer-stored so that nothing will be rewritten during the write cycle.

A basic memory system is illustrated in Figure 1. (If the system is random-accessed, associated address registers are also included to dictate location of the word to be read).

In operation, the "read" driver, triggered by a pulse from the timing circuit and switching system logic, generates a pulse of sufficient amplitude to switch the binary cell, thereby causing an output from the memory array. The pulse generated is directed to the proper word to be read by the decoder. To reduce noise, the output from the word selected in the memory array is amplified during only a portion of the read pulse; this amplifying period is controlled by a strobe pulse. The amplified output is then used to set the "flip-flops" of the buffer register into their appropriate states. The switching system logic will now perform any necessary operations on the information stored in the buffer registers.

The switching system logic generates a new word to be written, or passes on the previously read-out word for rewriting. This logic information is applied to the appropriate "inhibit" driver, coincident with the inhibit pulse from the timing circuitry. The "write" driver is triggered by the write pulse from the timing circuit, as it is directed

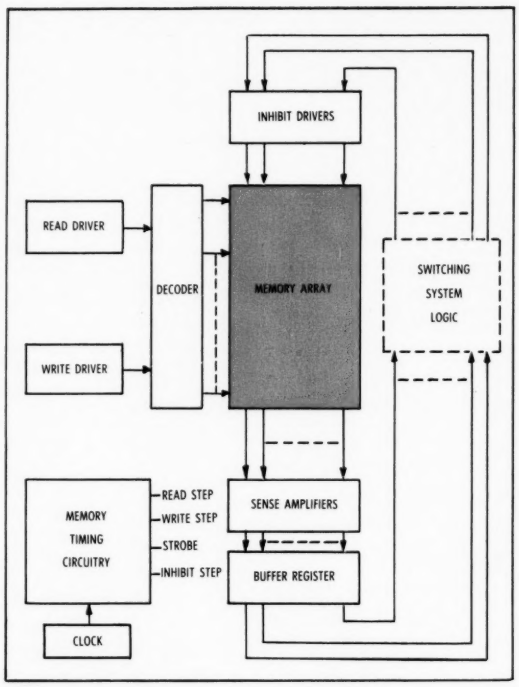


Figure 1. A Basic Memory System

once again by the decoder to the identical location in the memory array from which the last word was read. This completes one memory cycle.

A device which is to be accepted as a memory element must be capable, when interrogated, of furnishing information that is recognizable by external circuitry, to give an indication of the device's state. Such a memory element is called a *binary cell.*

The Binary Numbering System

The binary numbering system, composed of binary numbers (sometimes called "words") is the special language of the digital systm. It differs from the decimal counting system in that it uses the base 2 instead of the base 10. (The base of a numbering system is an indication of the difference between successive digits in a number of that system.) In the decimal system each successive digit it greater by a factor of 10; in the binary system the factor between successive digits is 2.

As an example, the number 10110 can be represented in the decimal system as follows:

$$1 \times 10^4 + 0 \times 10^3 + 1 \times 10^2 + 1 \times 10^1 + 0 \times 10^0$$

In the binary system 10110 can be represented as:

$$1 \times 2^4 + 0 \times 2^3 + 1 \times 2^2 + 1 \times 2^1 + 0 \times 2^0$$

and if we carry out these calculations further, we find that the number 10110 in the binary system is equal to $16 + 0 + 4 + 2 + 0 = 22$ in the decimal system.

The need for five binary cells to store a two-digit decimal number gives an indication of the amount of space required to construct a memory of 100 decimal numbers. Although the number of cells in a binary system is much higher, the overall system is much simpler than the use of special decimal storage devices which are usually slow and costly.

Types of Memory Devices

Magnetic Cores

Magnetic cores are one of the more common types of storage binary cells now in use. These devices, as well as other magnetic devices, depend upon magnetic flux remanence for operation. A magnetic flux will remain in a magnetic material

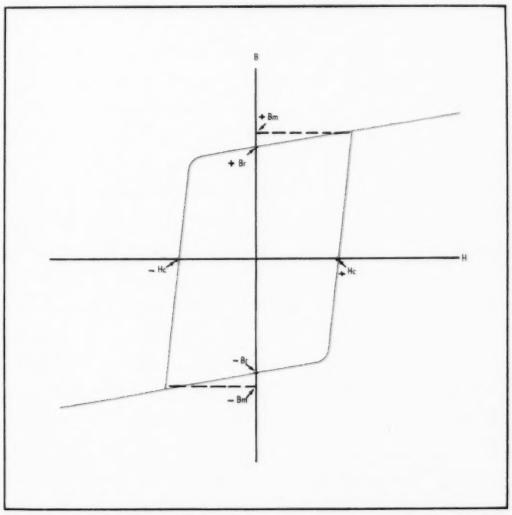


Figure 2. Hysteresis Curve of a Typical Core Material

for a period of time which varies with the material and the original strength of the flux. The remanence property of a typical core material is shown by the shape of the B-H or hysteresis curve illustrated in Figure 2. The points on the curve marked +BR and —BR are the respective storage states. Due to the squareness of the hysteresis curve, the core will retain a resultant magnetic flux, BR, produced by passing current through a "drive" winding on the core. The polarity of the resultant magnetic flux depends on the polarity of the current pulse.

The points in Figure 2 marked —Hc and +Hc signify the minimum current which must be passed through a particular winding to switch the core. The minimum coercive force (Hc) needed is usually expressed in ampere-turns for a particular core. Although this may range from ½ to 2 ampere-turns, the duration of these current switching pulses is in the microsecond range; by using many turns for the drive winding and microsecond current pulses the average power requirements can be kept very low.

Binary information storage is accomplished by assigning the +BR state the binary number "1," and the —BR state the binary "0." The binary stored number is determined by "reading" the core. This reading is achieved by applying a current pulse of sufficient magnitude to switch the core to the binary "0" state; by observing the induced voltage in a "sense" winding, the state of the core, prior to the reading pulse, can be determined. The induced voltage in the sense winding is dependent on the rate of change of the magnetic flux. If the core is in the —BR state the "read" pulse tending to switch the core to the —BR state results in very little flux change; any change which does occur is equal to (BM—BR). This small change causes a small voltage to be induced, which is the generated noise in the memory system. To reduce this noise, magnetic memory cores with very good squareness ratios BR/BM are required.

If the core is in the +BR state, the "read" pulse results in a very large flux change and a resultant large induced voltage pulse. In reading a stored binary "1," destructive readout takes place (the information is destroyed by switching the core). This necessitates external circuitry to temporarily store the read information, and then restore the core to its previous state, if the read information is not to be lost. This temporary storage function is performed by the buffer register.

Rewriting information into the memory from the buffer store is accomplished by controlling "rewrite" drivers using the information that has been "buffer stored," together with timing pulses from the system logic.

At the end of a rewrite period the buffers are reset. This places the buffer in the state it was in prior to receiving and recording information from

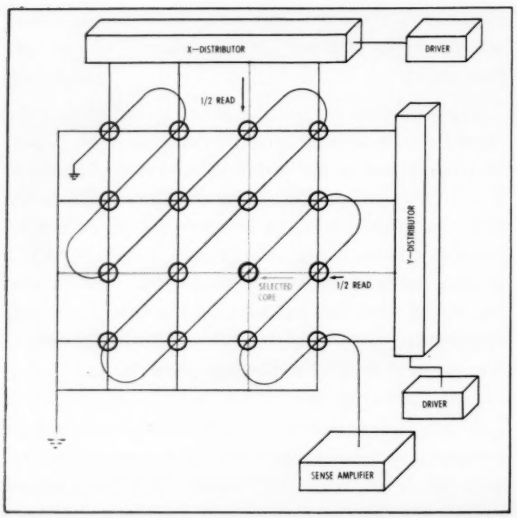


Figure 3. "Row-and-column" method of Memory-Core Selection

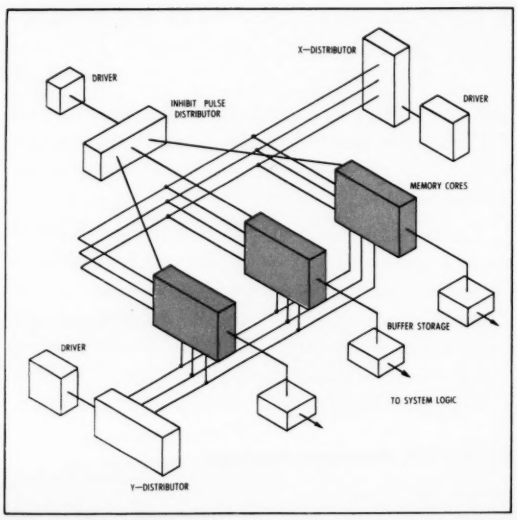


Figure 4. "Three-Dimensional" Memory System using Magnetic Cores

the main memory; it is again available to receive and temporarily store *new* information.

The magnetic core, requiring a certain minimum power for switching, enables one to construct a memory with a minimum of driver access circuitry. This is an advantage, since one of the most difficult and costly sections of any memory is the input access circuitry.

Selection Modes

Many otherwise good memory elements fail because of the amount of equipment they require to gain access to individual bits of stored information. On the other hand, certain memory elements have "built-in" access advantages; magnetic cores are among these elements. The big advantage is that they can be selected coincidentally. This is possible because of the particular shape of the hysteresis curve for a magnetic core, in that a definite minimum current is needed to change the flux storage state of the core. By placing one core at each intersection in a rectangular grid, and threading each horizontal row and each vertical column with separate windings, a "memory matrix" is constructed. Any one core in this matrix can then be switched by impressing on the proper "row" winding one-half of the current needed, and on the "column" winding the other half; the one core thus selected and switched will be at the intersection of the two windings. This particular selection method is shown in color in Figure 3, with associated distributor circuits. Memory arrays with 16, 32, 64, or 128 bits squared are common.

Although this technique is satisfactory for small memory systems, the large amount of external circuitry required puts it at a disadvantage for large systems. However, by including an "inhibit pulse" distributor, and an extra winding (called an "inhibit" winding) in each memory array, a large memory system using magnetic cores can be economically constructed (Figure 4). Each matrix in this system has cores that are selected exactly as shown in Figure 3. In this three-dimensional system, however, an "inhibit" winding is wound through each core in the matrix, and an "inhibit" current, of such magnitude as to cancel out one of the "half-write" switching currents, is applied to every matrix in the system, except the one containing the core to be switched. A three-dimensional system such as this has three distributors and associated drivers. The number of selection leads is $X + Y + Z$, and the number of storage cells is $X \times Y \times Z$; a memory system containing 16 arrays of 32 rows and columns per array will contain 16,384 bits.

A memory system is constructed so that groups of binary bits are read or written at one time. By applying a "half-read" pulse to the X and Y leads into the memory, an individual core in each matrix will be interrogated. Each matrix contains one bit,

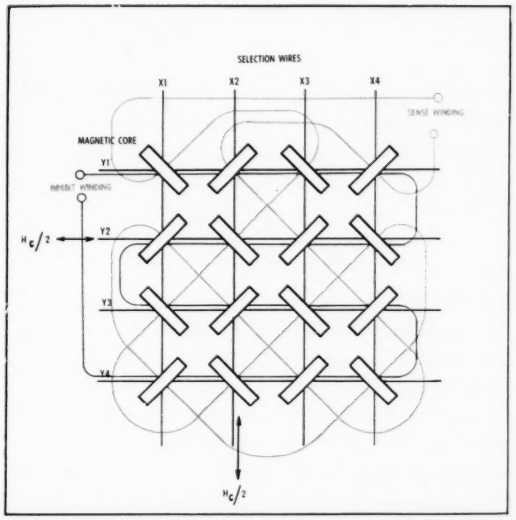


Figure 5. Inhibit Winding used with a Coincident-Current Memory Array

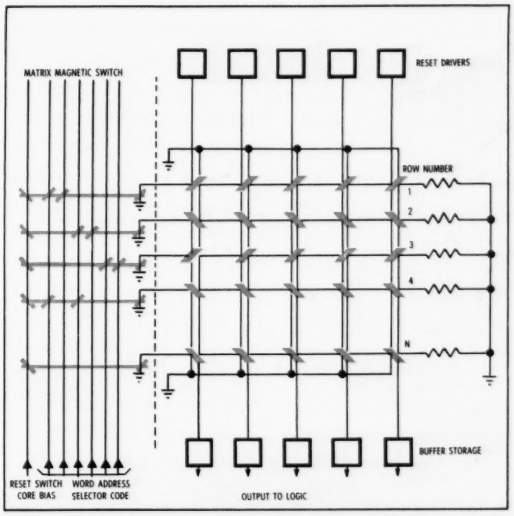


Figure 6. Word-Oriented Memory

forming part of a word, and there are as many matrices stacked up as there are bits in the word. To selectively control the simultaneous writing of "1's" or "0's" forming a word, each matrix contains an "inhibit" winding, threading all cores in the matrix. Figure 5 shows a winding arrangement which is used with coincident-current memory arrays; the "inhibit pulse" drivers in this system are controlled by the buffer register, containing the word to be written into the memory. By applying inhibit pulses to certain matrices in the memory system, a "0" is maintained in the coincidentally selected core: the other matrices (with no inhibit pulse) will contain the core that will be switched to the $+B_R$ or binary "1" state.

Since most of the noise generated in a magnetic memory array is due to the disturbed "0" voltage, such an array has practical limitations of size. However, arrays of 256 by 256 have been constructed with acceptable signal-to-noise ratios, by carefully selecting cores with good squareness (B_R/B_M) ratios, and using special winding techniques. One such technique is to arrange the cores and thread the sense winding in such a manner that the disturbed 0's tend to cancel out one another as shown in blue, Figure 5. There are other techniques which can be employed, such as "post-write disturb" pulses, and using two cores for each binary bit; these methods can be used separately or in combination, depending upon the memory function and requirement.

Memory arrays can be fabricated in which the information is "word-oriented"—that is, instead of reading a single bit from an array and grouping the binary bits read from several arrays to form a word, each array stores complete words. Selection is no longer established on a coincident basis; instead, access is gained through matrix switches. A row, or portion of a row of a memory array is read by applying a "full read" pulse to the selected row. Information is rewritten by coincident selection of the row and particular columns of the arrays (Figure 6). Since reading is not accomplished on a coincident basis, drive current in excess of that needed to switch the cores can be used for speeding up the read time, allowing more time for logic operation. This is one of the advantages of word-oriented memory arrays.

Memory cores are one of the many memory devices that can be used in practical memory systems; relays, ferroelectrics, storage tubes, and magnetic tape also achieve selection by spatial methods. That is to say, a stored bit is always located at a particular point in the memory array, and the reading of a bit of information is accomplished by examining the point in the memory system associated with that bit.

Delay Lines

There is another form of selection, temporal, in which the information is stored in an element of

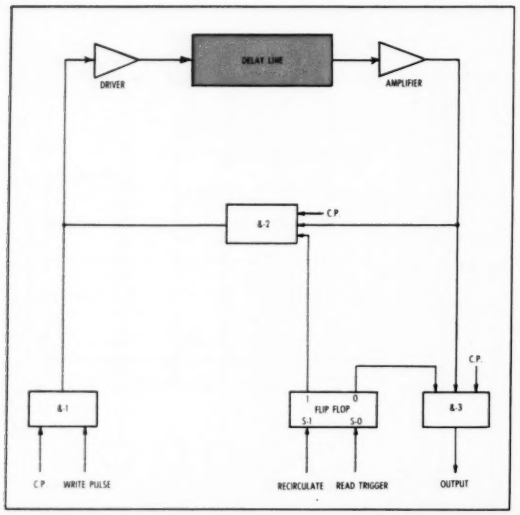


Figure 7. Delay-Line Memory

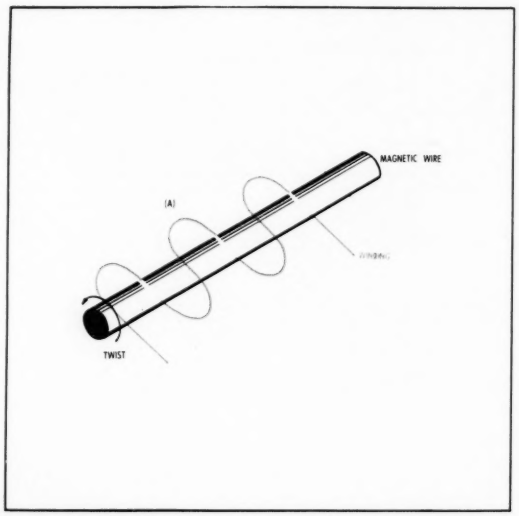


Figure 8. Principle of "Twistor" Element

time, thus allowing information to be available at discrete times only.

Delay-line memory systems employ this form of selection, and are the simplest and most economical of all. They do not require distributors, since the delaying element acts as a distributor by supporting the time-motion of information impressed with the delay medium. The information impressed on the input of the line will propagate at a rate determined by the properties of the line. As one bit of information moves down the line more bits can be put on the same line; the first bit is collected after a delay which is determined by the medium used for the line, and by its length.

A particular type of delay-line element is the "magnetostrictive" delay line, which takes advantage of the fact that certain materials change their physical size when placed in a magnetic field. This change creates within the material a stress, or shock wave, which travels along the line. To create a magnetic field and thereby introduce a "1" into a magnetostrictive delay line, an electromagnet coil is wound around one end of the magnetostrictive rod. By applying a current pulse to the coil, a magnetic field is established which causes a change of length of the rod; this change of length, proportional to the rate of change of the field, creates a proportionate shock wave which travels the length of the rod, at the speed of sound in the material of which it is made. At a given distance from the transmitting electromagnet a second, "receiving," coil is wound around the rod; this coil is kept in a biasing magnetic field supplied by a third coil, or by a small permanent magnet. When the shock wave passes under the receiving coil the permeability of the magnetic path is changed, inducing in the receiving coil a voltage which is proportionate to the rate of change of the shock wave. The induced voltage, proportionate to the transmitting coil magnetic flux d^2/dt^2, must be detected and re-shaped into the form of the original information, if it is to be recirculated or used in logic circuitry.

A block diagram of a delay-line memory is shown in Figure 7. In this system, writing is accomplished by supplying a write pulse, in coincidence with a clock pulse, to "&" gate No. 1. The output of this gate supplies a pulse to a driver amplifier, which causes the pulse to be impressed upon the delay line. Some time later the pulse is detected and amplified. Depending on the "flip-flop" logic, the pulse is either re-circulated through "&" gate No. 2 or read out through "&" gate No. 3. All "&" gates are supplied with a clock-pulse input for re-shaping and timing of stored information.

The capacity of a delay-line memory is determined by the delay provided in the line, and by the length of the stored pulses. Because it provides storage by delaying information, the delay-line memory has long access times. However, the simplicity of delay-line systems, and their low cost,

does definitely indicate certain uses in electronic switching systems.

The "Twistor"

If a magnetic wire is placed in a magnetic field, it tends to *twist,* and the magnitude and direction of the twist are directly dependent upon the magnetic field. A storage device, called the "Twistor"*, is based on the inverse of this effect.

As shown in Figure 8, switching is accomplished by passing a current through a coil around the magnetic wire. Many such coils can be wound on a single wire; the area under each coil then becomes a separate storage region. A "Twistor" may be selected coincidentally, by applying current to the coil, and to the wire itself. These devices offer promise from the standpoint of high switching speed, high-density storage, low drive-power requirements and economy of fabrication.

Practical Application of Memory

In electronic switching systems, the memory will supply the control information to the system. In specific application it could be desirable to have either a single central memory, or several groups of individual memories. Information content of these memories would include some or all of the following:

1. *Dial Pulses* — To establish a connection, the complete dialed number must be available to the system; therefore, storage of the dialed number, preferably in a binary code, must take place. Once the connection is established, the dialed number will serve to identify a particular connection in the crosspoint system, or to identify the time-slot in a time-division-multiplex system.

2. *Line Condition* — Marking of a line to indicate whether it is busy, out-of-order, or any other condition, can be accomplished in a memory. Line-condition storage would prevent seizure of a busy line, while switching-center control could still permit conference calls or emergency break-in.

2. *Ring-back* — Since the memory will already contain line-condition information, it can be used to trigger the necessary circuitry for ringing information, ring-back to calling party, and busy tone. Ringing information could be triggered by the memory; the storage content would tell what tone or code to ring for selective party-line ringing.

4. *Trunk Condition* — Just as the memory furnishes line conditions, so it can serve to indicate status of existing trunks.

5. *Timing Information* — To aid in the synchronization of a switching system, the memory can supply necessary "trigger" timing pulses, during any or all cycles of operation.

6. *Dialed Information* — If dialed pulses stored in the memory are those requesting special service, a translation memory could be used for interpretation. Dialed information such as out-of-order telephones, operator, long distance, information, and Direct Distance Dialing numbers could be memory stored.

7. *Directory Information* — In dialing from one office to another on local or long-distance calls, routing selection could be controlled by the memory. This would permit selection of available alternate routes to establish connections.

These are a few of the many possible uses of memories in electronic switching exchanges. As stated earlier, the versatility of these systems will be tremendously increased. And the application of memories will not be restricted to switching systems only. Another application would be in auxiliary equipment for billing the telephone subscribers. This system would identify the calling subscriber, time the call, and record all necessary billing data for processing with automatic accounting machines. Because, in this application, large quantities of information must be stored, magnetic tape or disks could be used. Short access time is not necessary since all data will be processed serially at the speed of the accounting machine's capability.

The work accomplished by Automatic Electric Laboratories takes in all phases of the usage of storage elements. Some research is being conducted in various physical phenomena in the search for new memory devices. Applications of presently known techniques, as well as newly discovered ones, are being investigated. Due to the importance of external circuitry connected with any memory, investigation in this phase is also going on.

Memory types, permanent and temporary, with destructive and non-destructive read-out characteristics are being considered. Capacities of memories under study vary from a few hundred bits into millions of bits. The speed of operation—that is, the "read-write cycle"—varies from milliseconds to microseconds.

A. H. Bobeck, "The Twistor," Bell System Technical Journal, Volume 36, November, 1957

new "SPACEMAKER*" telephone provides complete

"SPACEMAKER" PHONE IN THE KITCHEN

A Trademark of Automatic Electric Company

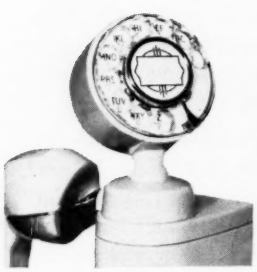
Since a telephone is such a personal thing, used intimately in the office and home, it must be not only efficient and dependable as an instrument of communication—it must also be *pleasing to the subscriber*. Telephone companies know how much easier it is to sell service when they can offer telephones with lightweight handsets, quiet dials, pleasing shapes, and attractive colors. And probably most commercial men can think of additional sales they could make if they could offer a telephone smaller than the standard desk and wall instruments, to bring telephone convenience into new places desired by subscribers. Laboratories has now developed such an instrument—the Type 183 telephone that mounts on only 3″ by 5″ of space, and is appropriately called the "Space-Maker" telephone.

Experience with earlier types of "compact" telephones (including A.E.'s Types 43 and 83), has shown, however, that while small size solves the problems of *mounting* a telephone, it does not always solve the problems of convenient *use*.

For example, sometimes a telephone must be mounted quite low, yet it is to be used mostly from a standing position. And sometimes the only space

Dial rotates 360°. Installer locks it in the position most convenient for the subscriber.

Receiver swings from side to side — a 180° arc. Installer locks it in the position most convenient for the subscriber.



Dial tilts up to 45°. Installer locks it in the position most convenient for the subscriber.

Simple angle bracket available —permits mounting at edge of horizontal surfaces.

...lexibility in use and mounting

available is in a corner, where the usual location of the handset, at the left of the telephone, may not be at all convenient for the telephone user. These difficulties were kept in mind in designing the "Space-Maker" telephone, with the result that this new instrument provides complete flexibility in mounting and in use.

It can be mounted in almost any location, because both the dial and the handset mounting can be placed in the positions that are most convenient *in that location.* Thus, the dial can be turned in any direction around a vertical axis, and up to 45 degrees above horizontal—and locked in that position by the installer. Similarly, the handset hook may be placed at the right or at the left side of the telephone, or at any one of five positions in between. From the mounting standpoint, this telephone may well be called "universal."

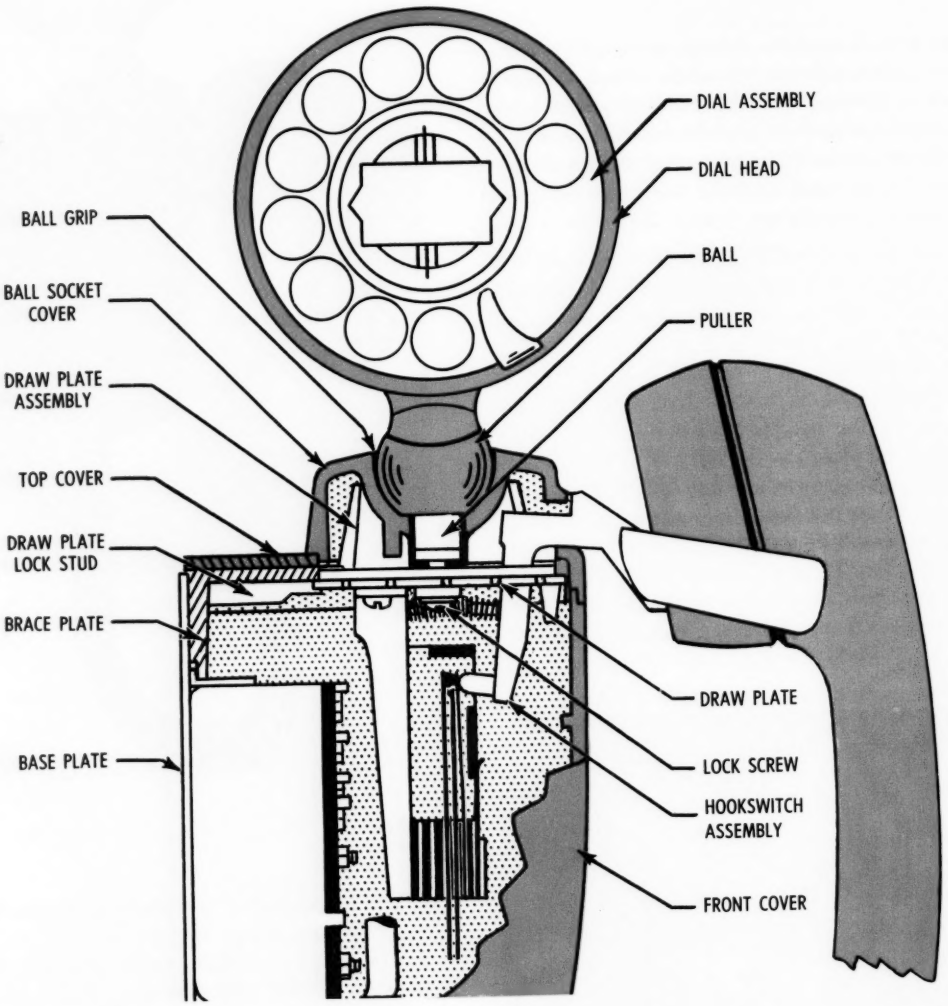
"SPACEMAKER" PHONE IN THE BEDROOM

The "Space-Maker" telephone is designed primarily for use as an extension; with its many features (including choice of ten colors and black) it offers telephone companies an ideal instrument for promoting the "second telephone" idea. The same instrument may, of course, be used also as a main-line telephone, in locations where its small size and flexibility make it particularly appropriate. It uses the same high-efficiency anti-sidetone circuit as the Types 80 and 90 telephones. It does not contain a ringer, but may be used with a standard ringer box; only two wires are needed

for connecting the "Space-Maker" telephone to the box, or to a main-line telephone.

The offset mounting of the dial permits installation of the "Space-Maker" on the side of a desk or table. A bracket is also available (see page 26) for other mounting requirements.

The "Space-Maker" telephone, latest product of Laboratories, is a new concept in telephone instruments, which will enable telephone companies to exactly meet many unusual requirements of their subscribers, with one highly flexible telephone instrument.



DESIGN FEATURES OF THE "SPACE-MAKER" TELEPHONE

The complete dial and hook-switch assemblies are supported by the brace plate, which is attached to the base plate on which the transmission unit assembly and the line compensator are mounted. When the telephone is installed, a single lock-screw is loosened to permit positioning of these assemblies. The hookswitch, mounted on a "draw plate," has seven notches, which match ears on the brace plate; the draw plate is simply rotated to the position desired, and drops into place and locked in this position by the lock stud. The dial assembly, on its ball-and-socket mounting, is turned to present the dial in exactly the position desired. The lock-screw is tightened to hold both the hook-switch and the dial in position.

AUTOMATIC RECORDER-ANNOUNCER FOR COIN DEMONSTRATION AND INTERCEPT SERVICE

By E. J. Glenner

In the training of toll board operators, it is vitally important that they learn to recognize the sounds of different coins deposited in a paystation; coin tones, as heard by the operator, sound quite different from those heard by the subscriber. Attempts to artificially synthesize these tones have produced approximations which were not entirely realistic.

To overcome this training difficulty, Laboratories has developed a Coin Demonstration Unit which accurately duplicates the sounds made by different coins as they are deposited in a paystation. The new unit can also be a ready reference for experienced operators who may be doubtful about coin sounds on a call; they can quickly dial the Demonstration Unit over another link, to check the coin tones. This same unit may also be used for intercept service.

The basic component of the Coin Demonstration equipment is the Automatic Recorder-Announcer Unit (Type MCF, Multi-Channel, Fixed message-length), shown in Figure 1. A magnetic drum is employed as the recording medium, using a pick-up head and playback (audio) amplifier for each separate message. The output of each playback amplifier is of low impedance (approximately 8 ohms) so that many callers can be served simultaneously without crosstalk interference. A "loop panel," with the recording medium and the pick-up heads, contains the equipment for controlling the announcer starting and stopping operations, in addition to alarm facilities. The playback amplifier is shown mounted at the top, and the loop panel below.

The Recorder-Announcer provides a message normally having a fixed length of 6½ seconds; if desired, a 12-second recording cycle may be obtained by a mechanical adjustment made at the loop panel. A portable "erase and record" amplifier may be provided for purposes of erasing and recording new messages.

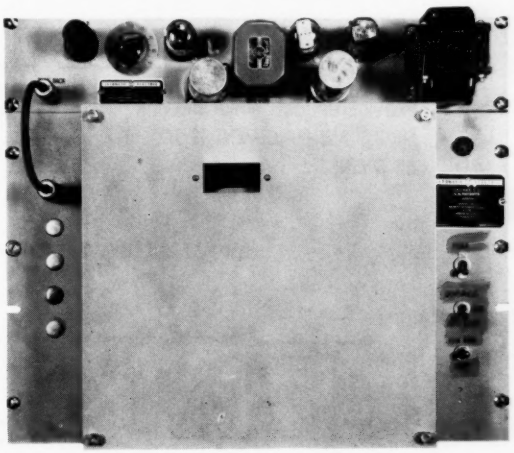


Figure 1. Coin Demonstration Unit

Coin Demonstration

Coin Demonstration equipment is normally accessed from the banks of auxiliary selectors. When the coin equipment is seized the operator will hear the recording, "nickle, dime, quarter" followed by the respective sounds of these coins being deposited in a paystation. The recording will be repeated each 6½ seconds until the operator releases the equipment.

This coin demonstration facility was originally designed to function in conjunction with the Type "FW-1" Intertoll Switching System (described in the December, 1956, and June, 1957, issues of the Technical Journal) but it can be adapted for general use with only a slight modification of the selector access equipment. Since the coin tones heard were produced by actually depositing the coins in a paystation and accurately recording their sounds, the Coin Demonstration Unit is a valuable aid in the training of new operators for paystation work.

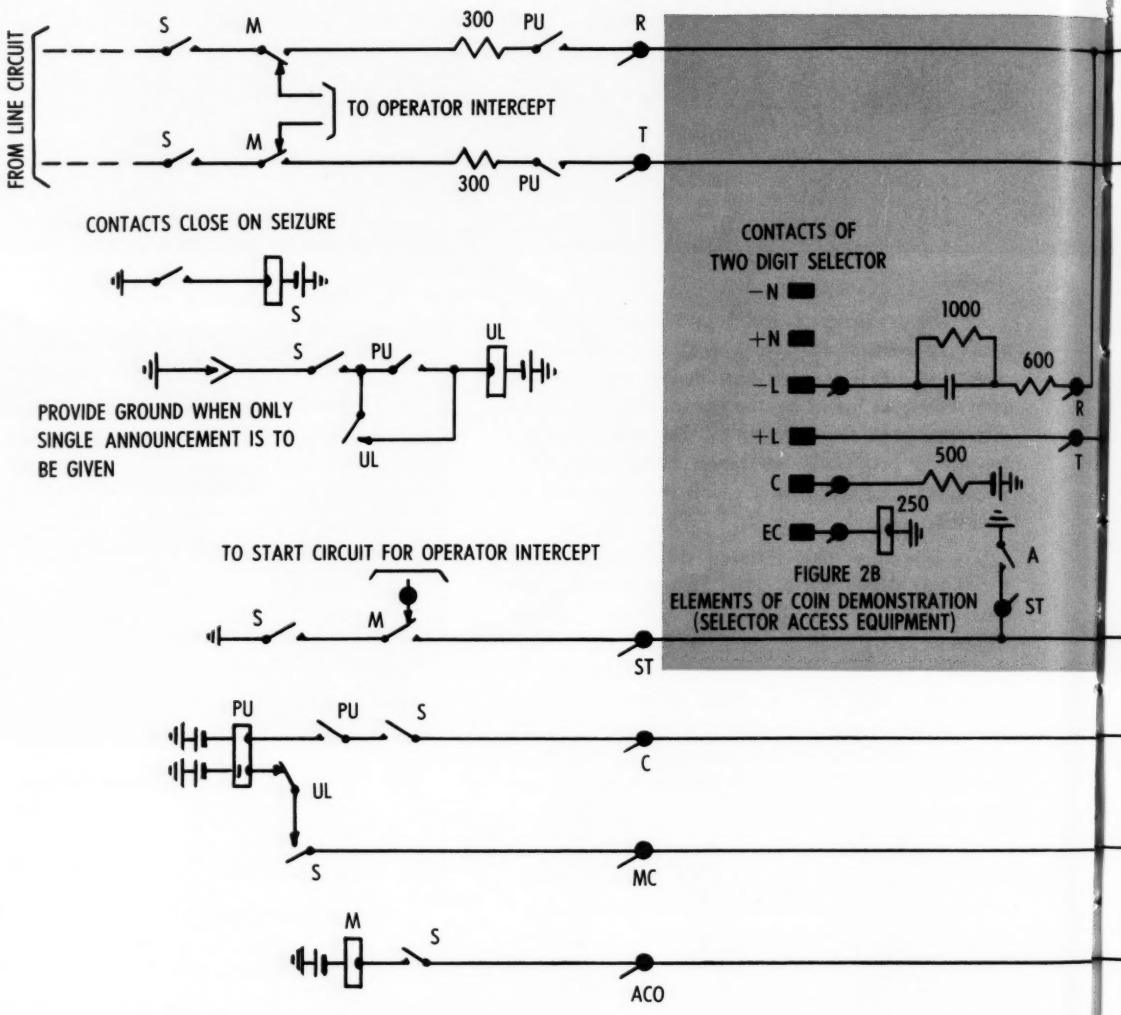


FIGURE 2A

ELEMENTS OF CONNECTOR LEVEL INTERCEPT CIRCUIT

Operation

The elements of the Coin Demonstration and Intercept Announcer are shown in Figure 2, with the auxiliary selector-access equipment as Figure 2B. When the code number is dialed, a start signal is passed to the loop panel (Figure 2D). If the unit is set for "start-stop" operation, the start signal will energize the drum motor and clutch magnet to cause the magnetic drum to rotate. The coin demonstration sounds are thus passed to the operator. Continuous operation may be obtained by operating the "playback" key on the loop panel.

Cam springs are provided on the loop panel as an indexing point for the announcement. When the drum begins to rotate and start the announcement, cam springs operate (move "off-normal"); when the drum rotates to its normal position, the cam springs restore. Thus, if the operator releases the unit in the middle of the announcement, the cam springs will serve to re-index the drum to its normal starting point, ready for the next seizure.

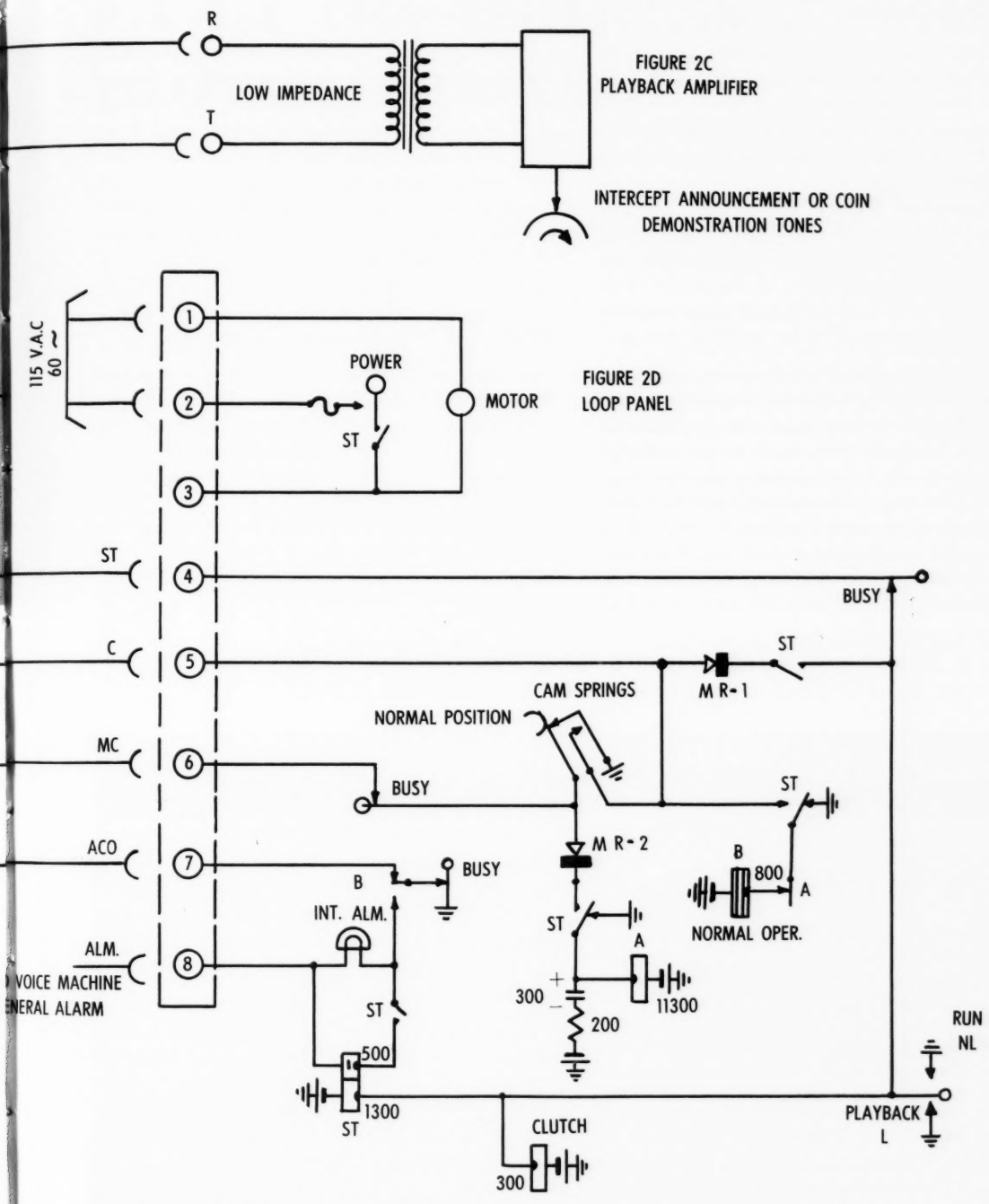


Figure 2. Elements of Coin Demonstration Unit and Intercept Announcer

Intercept Announcing

The same loop panel and amplifier equipment used for coin demonstration purposes can be utilized for intercept announcing by merely recording the appropriate announcement on the magnetic drum. In this capacity it serves as a useful device for disposing of calls to disconnected, unassigned or dead numbers. When a number is to be placed on intercept service the dialed line equipment is accessed by a connector-level intercept circuit, the elements of which are shown in Figure 2A. This circuit is, in turn, routed either to the Automatic Recorder-Announcer, or to an intercept operator.

When the intercept circuit is seized, a signal is given to start the Recorder-Announcer loop panel (Figure 2D). As the loop-panel cam springs move off-normal, a signal is returned to the intercept circuit (on the "C" lead) to close the line leads so that the intercept announcement may be heard. The intercept equipment is optionally arranged to give repeated announcements or to cut-off the line leads after a fixed number of announcements; Figure 2 illustrates cut-off after one announcement.

If the loop equipment is busied out, lead ACO will not be grounded, and when the intercept circuit is seized, it will be routed to an operator.

Alarm Conditions

The loop panel is provided with alarms so that failure of the recorder equipment will be quickly reported. It may be noted that both relays A and B of Figure 2D are normally operated, and if no trouble occurs they will both remain operated. Under normal operating conditions, when the recorder is started (and running), the circuit will be opened to relay A for 6½ seconds and only momentarily closed each time the cam springs are actuated at the starting point. Relay A has a high-time-constant condenser-discharge circuit, and a release time of approximately 10 seconds.

If a d-c power failure should occur, relays A and B will restore and signal an alarm. If an a-c power failure should occur with the cam springs at normal, relay B will restore when ST operates. If an a-c power failure should occur with the cam springs off normal, relays A and B will release (in approximately ten seconds) and signal the alarm.

In addition, the above alarm is given if a mechanical bind or failure prevents the drum from being properly rotated upon seizure. Here, as with an a-c power failure, relay B (or relays A and B) will restore to give the alarm.

MEMBER OF TECHNICAL JOURNAL EDITORIAL BOARD RETIRES

LEONARD L. RUGGLES, chief telephone engineer of Automatic Electric, and a member of our Editorial Advisory Board, retired at the end of November, after nearly 41 years of service.

Holder of 13 U. S. patents, Mr. Ruggles is credited with several important developments in automatic switching systems. He started as a student in Automatic's training school in 1919, and during his long career he was at various times assigned to the factory, engineering, sales, and laboratory organizations.

In 1954, he was the recipient of the Talbot G. Martin Award presented by the Strowger Automatic Club, an employee organization, for his outstanding contributions to the art and science of communications. His name is familiar to many telephone men who have met him, heard him speak, and read many papers in this and other telephone publications.

A veteran of World War I, and graduate of Purdue University, Mr. Ruggles is a member of Tau Beta Pi and Eta Kappa Nu, honorary engineering fraternities, and of the Western Society of Engineers, and is a Fellow of the American Institute of Electrical Engineers.

On his retirement, Mr. Ruggles was honored at a banquet attended by some 120 of his fellow employees. In addition to a slide projector, he was presented with a plaque, commemorating his outstanding service to the company, by President Herbert F. Lello.

P-A-B-X CALL RESTRICTION IN MODERN TELEPHONE NETWORKS

By L. L. Smith

The use of restrictors in P-A-B-X's to prevent unauthorized extensions from making toll calls is not a modern innovation; simple circuits have been used, for many years, to prevent access by certain stations to the central-office toll recording trunks. An attendant accesses the trunk at a point beyond the restrictor; thus it is possible for the attendant to use the central-office trunk to complete toll calls.

With Direct Distance Dialing of both nationwide and short-haul toll calls, it is desirable that all *authorized* calls from P-A-B-X's be completed via DDD, in order to fully realize the efficiency and economy of this new method of operation; this has greatly complicated the task of restricting *unauthorized* P-A-B-X extensions from making toll calls. Call restrictors have been developed to provide three classes of restriction to P-A-B-X extentions on outgoing calls from the P-A-B-X to the central-office: 1. Full restriction; 2. Restriction to local calls only; 3. Unrestricted service.

(1) Full Restriction

Full restriction of service to any extension is simply accomplished by preventing the station from accessing the central-office trunks. A fourth-wire marking is used to identify such calls to the P-A-B-X selector or switch-through connector; this prevents the selector or connector from stopping and switching through on an idle trunk. The marking may be obtained from the line equipment, or from the linefinder if the restricted extensions are grouped on the finder banks on a level basis. Fully restricted extensions may not make a local or toll call, except through the attendant's cabinet. Figure 1 shows a schematic of the restriction feature of a selector.

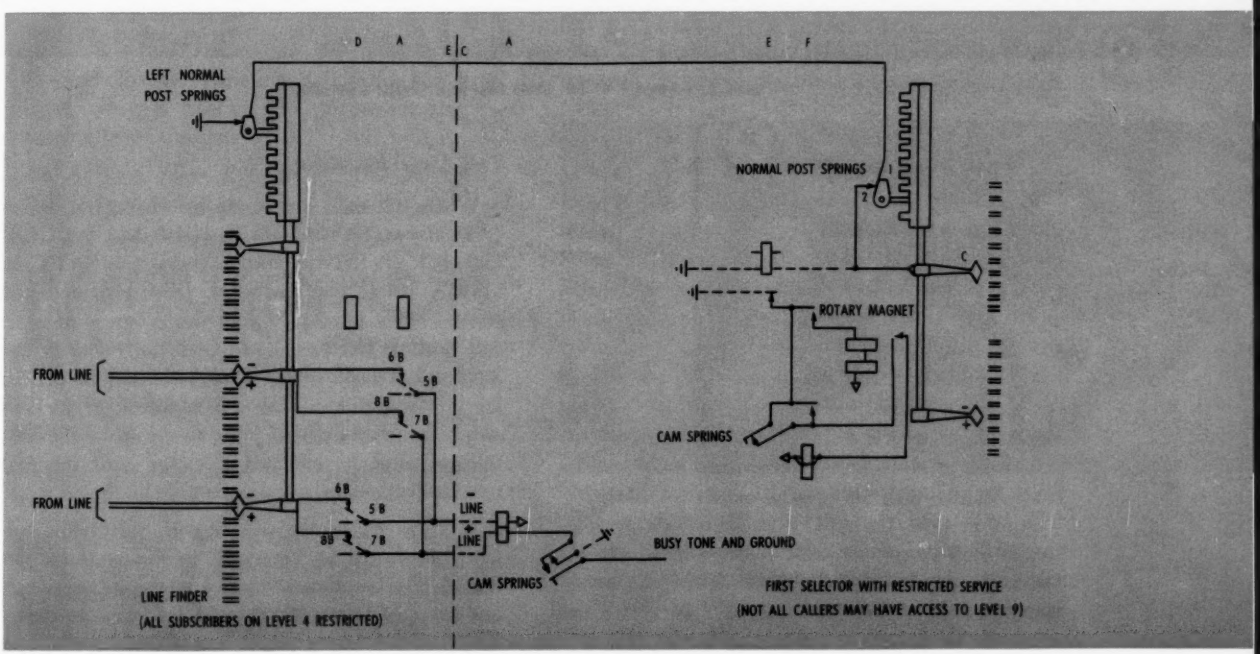


Figure 1. Selector Resistriction Features

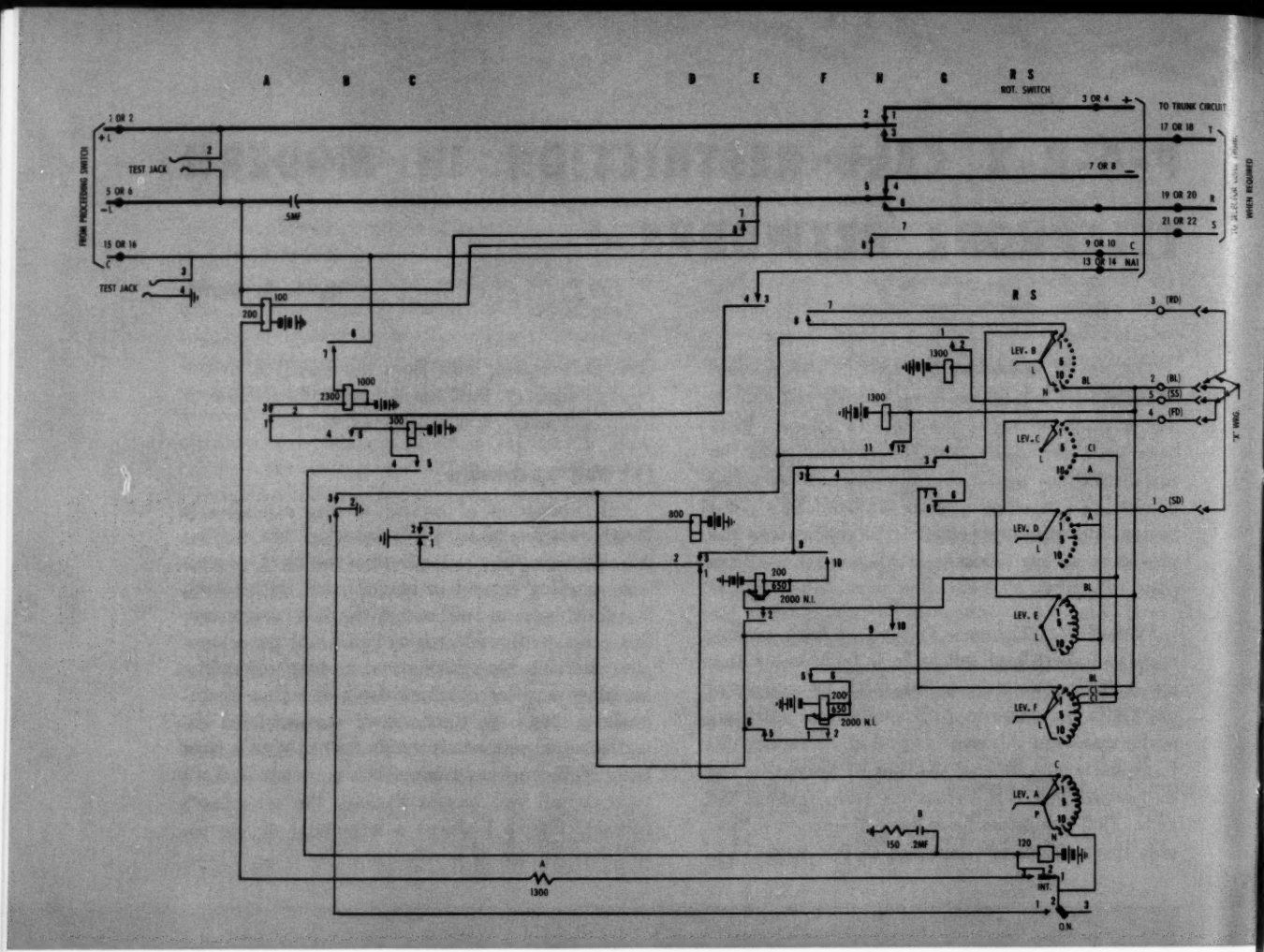


Figure 2. Schematic of Toll Code Restrictor Circuit Operation

(2) Restriction to Local Calls Only

Permitting an extension to make local central office but not toll calls requires that the distinguishing digits dialed by the extension be registered and checked to determine if an attempted call is a local call or a toll call. Two types of restrictors are available for this purpose. One, called the Toll Code Restrictor, is arranged for use in areas where all toll calls are completed either via the operator, or via a SATT or CAMA trunk accessed on a code basis; since only a few codes need be checked, this restrictor is not complex. The other type, the ABC and Toll Code Restrictor, is used to restrict calls in areas in which AB toll calls may be made without dialing an access code, and it is therefore necessary to check the ABC digits dialed, to determine if the call is a toll or local call.

Toll Code Restrictor

When toll calls are made by dialing an access code, the codes used are 0, 110 & 211 for CLR, and 112 or 150 or similar codes for SATT or CAMA calls. The restrictor (one provided per central-office trunk) follows the progress of each call until it has progressed past the point in the local switch train where a toll code may be dialed. In offices arranged for 2-5 numbering, for example, all digits dialed prior to cut-in of the first selector must be checked, because until the first selector has cut-in, a toll code may be dialed.

A Type 44 rotary switch with split wipers is used, as shown in Figure 2, to follow the digits dialed. The contacts of level A of the rotary switch are strapped to the BL (block) lead in accordance with the toll codes which are dialed on the first selector (for example, when 0 is used as CLR

code, the 0 contact on level A is connected to the BL lead). When CLR or SATT trunks are accessed via special second selectors, the CI (legitimate call) lead is connected to contacts on level F which correspond to the last number of the legitimate special-service codes, such as Information (113), and Repair (114).

On the first digit the wipers of levels B and C are positioned to check the nature of the digit dialed. The subsequent action of the switch is as follows:

If the first digit is a restricted digit, relay H operates to block the call or to transfer the call to a recorded message or to the attendant.

If it is a legitimate (CI) digit, relay E operates to disconnect the restrictor from the call.

If it is an A digit, relay F operates, and the rotary switch is homed.

If it is an AR digit, the rotary switch homes.

If it is a special-service code beginning with digit "1," relay G operates, and the remaining digits are checked on level F.

If the first digit was an A or AR digit or the digit "1," the second digit is checked on levels D and F. If the second digit is:

A restricted digit, relay H operates to block the call.

Preceded by an A digit and is not a restricted digit, relay E operates to disconnect the restrictor from the call.

An A digit, relay F operates, and the rotary switch is homed.

An AR digit, the rotary switch homes.

The second digit of a special-service code, such as 113 or 114, the rotary switch is homed.

If the second digit was an A or AR digit, or the second digit of a special-service code, the third digit is checked on levels B, E, and F. If the third digit is:

A restricted digit, relay H operates to block the call.

Preceded by an A digit and is not a restricted digit, relay E operates to disconnect the restrictor from the call.

An A digit, relay F operates, and the rotary switch is homed.

An AR digit, relay H operates to block the call (the normal office code would require the dialing of an A digit no later than the third digit).

The last digit of a legitimate special-service code, relay E operates to disconnect the restrictor from the call.

If the third digit is an "A" digit, the fourth digit is checked on level B to ensure that a restricted digit is not dialed. If the fourth digit is not a restricted digit, relay E will operate and disconnect the restrictor from the call.

ABC and Toll Code Restrictor

To provide effective restriction of toll and multimessage unit calls in a large metropolitan area requires the registration of the first three digits dialed, as certain of the ABC codes will be free calls, and others will be AB toll or extra-charge calls. In some offices it will be possible to dial DDD calls without dialing an access code first. Figure 3 is a block diagram of a restrictor arranged to function on the basis of an ABC code, or the first three digits dialed. Since a large number of calls must be checked, the registers are provided on a common-pool basis; for example, three or four registers may be provided for a group of 20 two-way central-office trunks.

To associate a register with a call, a trunk adapter is provided for each central-office trunk. When the trunk is seized, the trunk adapter closes a start

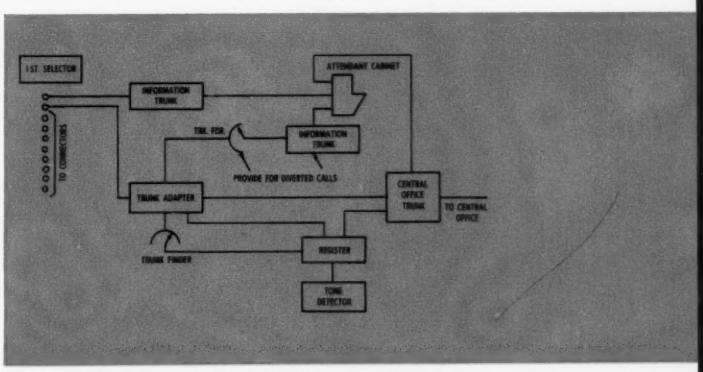


Figure 3. Block Diagram of ABC Code Restrictor

lead to the common pool of registers. When a register becomes associated with the call, the loop to the central-office repeater is connected through the register to the calling extension; dial tone is then extended to the calling party. If the extension

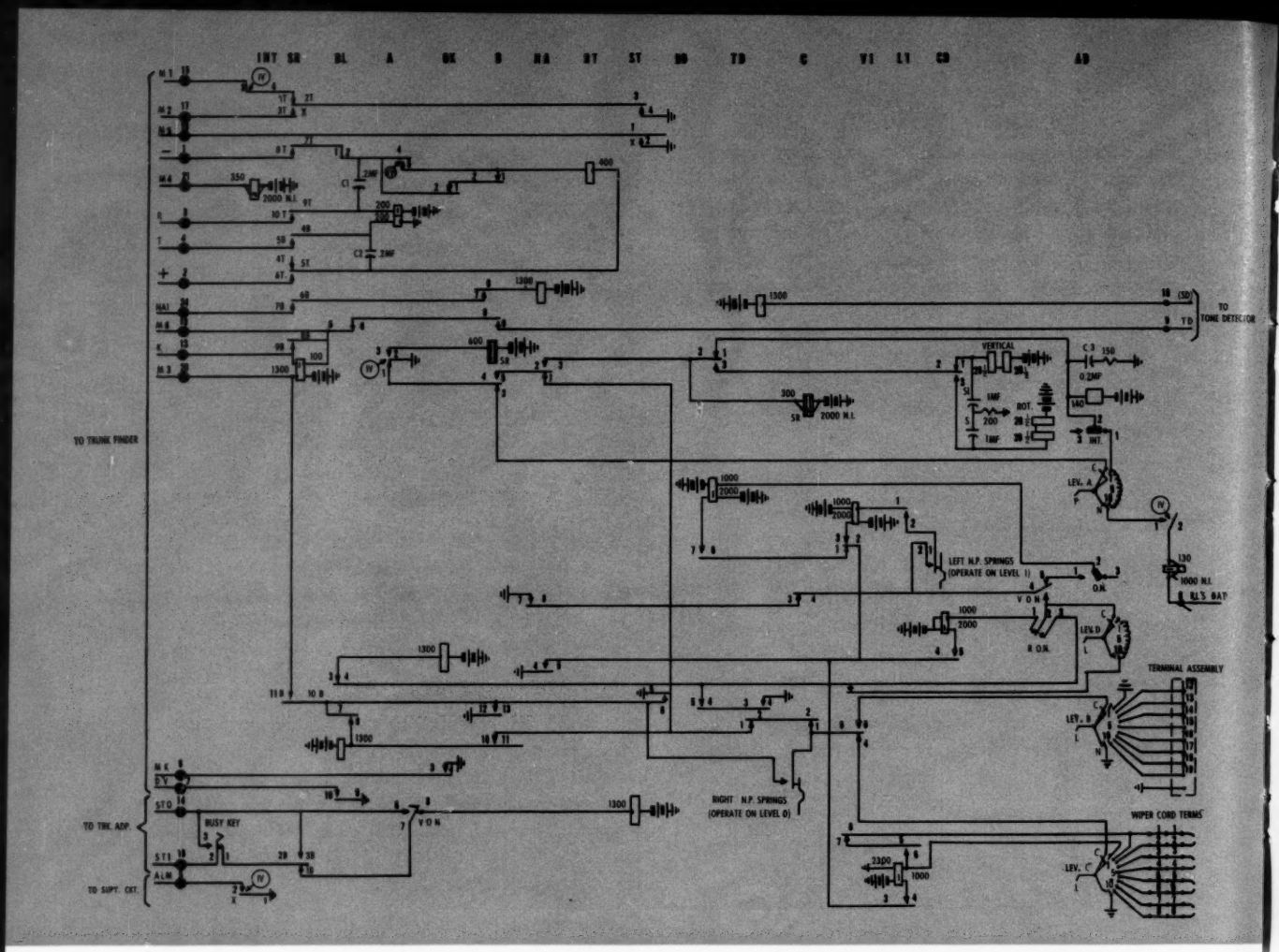


Figure 4. Schematic of ABC and Toll Code Restrictor Circuit Operation

attempts to dial before the register is associated with the call, or before the finder in the central office has found the calling line, the call is automatically disconnected, as it is assumed that the extension is attempting to evade the restrictor. Thus, it is impossible to override the restrictor by dialing quickly.

All digits dialed operate the central office equipment directly, but the first three digits of the number dialed are also recorded in the register (see Figure 4). The first digit is recorded on a Type 44 rotary switch; the second and third digits, on a standard Strowger switch with eight wipers and an 800-point bank. The rotary switch selects the appropriate wiper to be used for all ABC codes that begin with the digits 2 to 9; in conjunction with the 800-point bank on the Strowger switch it permits a choice of 100 codes (the maximum for any one initial digit) to be registered and checked for each dialed code beginning with any of these digits. All codes beginning with the digit 0 are restricted; therefore they need only be registered on the rotary switch, and do not require a level assignment on the Strowger switch. Special-service codes such as 113, 114, etc., are registered on level B of the rotary switch bank.

Two types of trunk adapters are provided for use with the ABC code restrictor. One type releases the connection if a restricted code is dialed; the other diverts the call to the attendant. The latter type would be particularly applicable for use in motels and hotels, where it is not the intent of the management to prevent such calls, but rather to have them completed by the attendant so that the call charges may be obtained and added to the guest's bill.

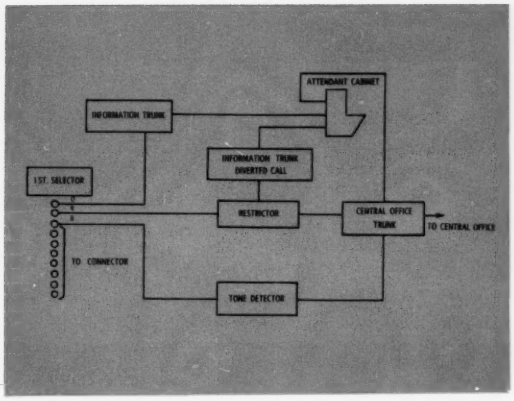


Figure 5. Block Diagram showing Second Access for Unrestricted Calls in a P-A-B-X System

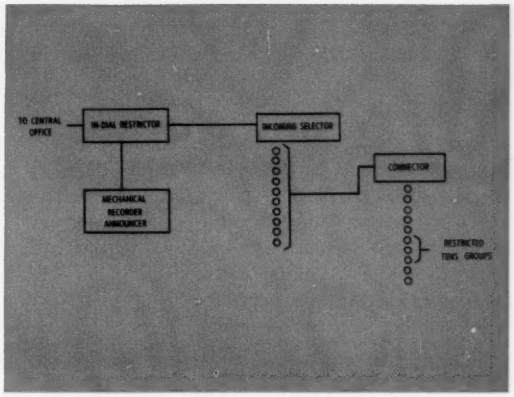


Figure 6. Block Diagram showing Inward Dial Restriction for a P-A-B-X System

(3) Unrestricted Calls

In many P-A-B-X's it will be necessary to allow certain extensions to make unrestricted calls over the central-office trunks. When the simple toll code restrictor, previously described, is used it is necessary to provide a second access (shown as level 8, Figure 5) to the trunk. To prevent extensions that are restricted to local calls from using this access, a tone-detector is provided between the selector and the trunk. These extensions are identified by a tone on the "C" lead, which activates the tone-detector and releases the connection. Unrestricted extensions would not have tone on the "C" lead, and the call would proceed normally. The ABC code restrictor includes a tone-detector associated with the common equipment; in this case the presence of a tone on the "C" lead indicates a non-restricted extension, and when the tone is detected the common equipment disconnects from the call and allows it to proceed normally. Only one selector level is therefore required for access from non-restricted and semi-restricted stations.

Inward-Dial Restriction

Inward dial operation of P-A-B-Xs has become more common in recent years, and if this trend continues it will become the standard mode of operation. There is usually no need for restriction on in-dial calls, since they do not involve a direct expense to the customer. However, there may be some stations where inward service is not considered essential; if calls to such stations would necessitate additional trunks, the use of a restrictor is justifiable.

An existing P-A-B-X can be arranged for in-dial restriction by segregating, in a particular connector group or on specific connector levels, all the extensions to be restricted. Access to an entire connector group can readily be blocked or interrupted on a preceding selector. However a special inward restrictor is required to block calls to certain tens-groups (specific connector levels). This restrictor may be located between the incoming selector and the central-office trunk, as shown in Figure 6. It receives the pulses from the central office, repeats them to the incoming selector, and initially records each digit dialed, so as to determine when the restricted or non-restricted digit is dialed. The particular tens digit which determines the disposition of the call is checked on a numerical basis. If it is a non-restricted digit, the restrictor extends the central-office trunk directly to the incoming selector, and the call proceeds normally. If the dialed digit indicates that a call is being attempted to a restricted station, the call is transferred to a mechanical recorder-announcer, which tells the calling party that the call must be handled via the attendant.

Other simpler methods are available for new jobs specifically engineered for inward dialing.

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